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PART I. VOL. XXVI.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

SESSION 1898-99.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME TWENTY-SIXTH.

PARTS I.—XIX.

FOR SESSIONS 1898-9, AND 1899-1900.

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UNIV. OF
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ERRATUM:—In Part XVII., Vol. XXVI., page 486, eleventh line from the top, for "George H. Martin," read "George H. Morton."

UNIV. OF CALIFORNIA

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XXVI. SESSION 1898-99.

The ANNUAL MEETING of the Members was held on Tuesday, October 11th, 1898, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street.

The President, Mr. JOHN RIDYARD, F.G.S., in the Chair.

The Annual Report of the Council for the past year was submitted, as follows:—

REPORT OF THE COUNCIL,

FOR THE SESSION 1897-98.

In presenting the Sixtieth Annual Report the Council have much pleasure in congratulating the members upon the good results of the year's work, as set forth in the following statements.

The Annual Meeting and six Ordinary Meetings were held in the Society's Rooms; two Ordinary Meetings were held, as usual, in the Mining School, Wigan. A Special Evening Meeting was held in January, in the Museum Buildings, Owens College.

The Council are pleased to record their thanks to the President for his interesting and entertaining address "On the Utility of Association for the Promotion of Science and of its Application"; and also to the authors for their

respective communications, which appear in the Transactions, and who have so ably assisted in maintaining the objects of the Society, namely:—"The collection and diffusion of knowledge respecting geology and mining."

Important papers on mining subjects have been contributed by Mr. Frederick G. Meachem, Mr. James Tonge, Mr. D. H. F. Mathews, Mr. H. Bigg-Wither, Mr. Thomas Ward, Mr. Henry Hall, Mr. William Saint, Mr. George Caldwell, and Mr. Joseph Dickinson; the latter, it is hoped, will, with the present and expected further discussion, form an exhaustive paper "On Subsidence caused by Colliery Workings."

Communications of geological interest were read by Mr. G. C. Greenwell, Prof. W. Boyd Dawkins, Mr. George Caldwell, Mr. W. E. Hoyle, Mr. Herbert Lloyd, Mr. W. S. Gresley, Mr. Robert Humphrey, and Mr. Mark Stirrup.

Valuable Geological specimens were exhibited by Messrs. J. Barnes and W. F. Holroyd and by Mr. William Saint.

Amongst other valuable specimens received, particular mention may be made of a collection of fossil fishes and reptiles, obtained from the Jarrow Colliery, Co. Kilkenny, by Mr. Joseph Dobbs.

There has been a considerable influx of new members, thirty having been elected during the sessional year: on the other hand the losses have been sixteen, including four by death and twelve by resignations. Eighteen names have been removed from the list.

Of the four deceased members whose names we regretfully record, Mr. H. M. Ormerod was a recently elected honorary member, and he and Mr. James Heywood, F.R.S., were Past-Presidents. With these two gentlemen the names of the founders of the Society have all disappeared from the roll of membership.

The Society now consists of—

Honorary Members	12
Life Members..	8
Ordinary Members	213
Total	233

Three Excursions took place during the session.

The first on 20th November, 1897, to the Clock Face Colliery, belonging to the Bold Hall Estates Co., Ltd., under the leadership of Mr. Fairclough and Mr. Henry Wall. About forty members attended. They were entertained to luncheon by Mr. Fairclough, Chairman of the Company, and afterwards proceeded to the Colliery, where they viewed the cores of the boring and the surface works.

The second, on 3rd September, 1898, to Hope and Castleton, under the leadership of Messrs. Holroyd and Barnes. The excursion was postponed from August 27th, owing to the wet weather. The party reached Hope at 3 p.m., and walked through the lanes to Pin Dale, where sections of the Carboniferous Limestone and chert beds were shown. At the head of Pin Dale, the quartz rock and quartzose limestone were examined *in situ* and specimens obtained. A paper was read by the leaders criticising the recent paper on the Quartz Rock, by Mr. H. H. Arnold-Bemrose, and offering new suggestions as to the mode of its deposition.

The third excursion, on 24th September, 1898, to the Maypole New Winning, belonging to the Moss Hall Coal Co., Limited, under the leadership of Mr. James Keen. Mr. Keen took a number of the members down both shafts, and also produced a section of the strata passed through in No. 2 Pit. As the shaft passed through a small fault at the Ince Seam he promised to send a carefully prepared section of No. 1 Shaft, when sunk through these seams.

The Treasurer's Statement of Accounts, hereto appended, shows the financial position of the Society to be satisfactory.

Dr. MANCHESTER GEOLOGICAL SOCIETY—BALANCE SHEET FOR YEAR 1897-8. *Cr.*

Abstract of Receipts.	£	s.	d.
To Birkenhead Railway Co. Dividend	11	12	0
,, Do. do. do.	11	12	0
,, Lancashire and Yorkshire Railway Co. Dividend	10	12	7
,, Do. do. do. do.	10	12	7
,, Colliery Managers' Association	2	10	0
,, Marshall, Gibbon & Co., Collectors	224	10	0
,, Bank Interest	0	8	10
,, Sir U. J. Kay-Shuttleworth, Subscription	1	0	0
,, Transactions sold	2	7	6
,, Lancashire and Yorkshire Railway Co., changing Shares to 3 per cent.	0	7	4
,, James Tonge, Petty Cash	5	0	0
,, Balance due to Treasurer	5	13	1
	£286	5	11

Abstract of Payments.	£	s.	d.
By Balance due to Treasurer	36	4	3
,, Library	1	19	0
,, Transactions	105	19	10
,, Circulars and Stationery	10	18	7
,, Reporters	10	10	0
,, Expenses of Rooms, Rent, &c	78	2	1
,, Postages	24	1	7
,, Electric Lighting	2	16	9
,, Type Writing	0	2	6
,, Fire Insurance	0	3	2
,, New Furniture	2	12	6
,, Collector's Commission	11	2	0
,, Transfer Fee	0	2	6
,, Cash in Secretaries' hands	1	11	2
	£286	5	11

The Investments consist of £600 Birkenhead Railway Consolidated Stock (Guaranteed); and £733 Lancashire and Yorkshire Railway 3 per cent. Consolidated Preference Stock issued in place of £550 4 per cent. Stock.

October 11th, 1898,

CLEGG LIVESEY, Treasurer.

October 25th, 1898, Audited and found correct,

(Signed) GEO. H. HOLLINGWORTH.
H. A. WOODWARD.

The Council, whilst feeling gratified with the unusually large influx of new members, would urge upon the members generally the importance of still larger accessions to the Roll of Membership, with the object of increasing the usefulness of the Society and its present income at the same time, and thereby enable the liabilities of the Society, chiefly in respect of printing, rent, rates, and room-attendant to be met without encroaching upon the invested funds.

The usual publications have been received from kindred Societies with which we exchange Transactions, and these, together with the Library and the Geological Maps of the District, are available for reference by the members, daily, between the hours of 9-30 a.m. and 5-30 p.m., except on Saturdays, when the rooms are closed at 1 p.m.

Our Honorary Member, Mr. William Whitaker, F.R.S., has again favoured the Society by giving a series of valuable standard geological books and pamphlets, and through him we have also received donations of valuable books from Mrs. A. H. Green, the widow of the late Professor of Geology at Oxford, and from Mrs. Topley, the widow of the late Mr. W. Topley, of the Geological Survey.

The cordial thanks of the Society are due to the authorities of The Owens College for the free use of the Lecture Theatre during the Special Meeting held there in January; and also to the Governors of the Mining School, Wigan, for the free use of the building in which the Ordinary January and May Meetings were held.

The Council have appointed a Committee who, in conjunction with the Committee of the Manchester Museum, will continue the work of the systematic collection and tabulation of the fossils of the Lancashire and surrounding coalfields; the object being to ascertain, as far as possible, the vertical range and horizontal distribution of each species. With this object a circular letter, a copy of which

is appended, was issued in July last to a number of Colliery Proprietors and others in the Lancashire and surrounding coalfields. They appeal to all interested in such work, and especially do they solicit the help and co-operation of Colliery Owners by encouraging their officials to give their assistance in this work. It is believed that the inquiry will result in affording data, not only of great scientific value, but also of practical use to those engaged in the development of the mineral resources of the district.

In conclusion, the Council, in reviewing the work of the past year, confidently rely upon the continued efforts of those members who have taken an active part in promoting the objects of the Society, and they also cordially appeal to the general body of members to assist by taking a personal share in the Society's proceedings.

Copy of the letter referred to in the Report :—

MANCHESTER GEOLOGICAL SOCIETY.

INSTITUTED 1838.

Queen's Chambers, 5, John Dalton Street,
Manchester, July 22nd, 1898.

Dear Sir,

The Committee of the Council of the Manchester Geological Society, in conjunction with the Commitee of the Manchester Museum, Owens College, has recently had under consideration the advisability of again asking the attention of Colliery Proprietors to the necessity which exists not only of a larger and more intimate knowledge of the features which distinguish the various beds which go to make up the Coal Measures of Lancashire and the adjoining district, but also to the encouragement of a systematic collection of their fossils.

The present time seems an opportune one to bring this subject under your notice, seeing that you and other proprietors are already engaged in explorations having for their object the proving of new ground, or the deepening of already existing pits.

The main object which the subscribers have in view may perhaps be better understood by the following paragraphs, extracted from the

circular on the same subject issued by the Manchester Geological Society in January, 1893:—

"The object in view is to ascertain the distribution in time and space, or in other words, the vertical and horizontal distribution of all fossil organisms, plant and animal, which are to be found in the Coal Measures, to note their presence, relative frequency and abundance in certain beds, and to record any facts that may come to light with regard to their life-history.

"The information thus gathered will, it is expected, be of great scientific value, and it is confidently hoped that it will be the means of determining and correlating the various seams in different parts of the coalfield whose position is doubtful, and which have been disturbed by faulting and other causes.

"Similar work has long been accomplished in many of the Continental Coalfields, enabling the Palæontologists to guide with success the researches of those exploring new or unknown ground.

"On these grounds the Committee appeal to all interested in such work, and especially do they solicit the help and co-operation of Coal Owners and their Agents, who, by encouraging their Managers to give their assistance, and by according them permission to collect and forward, from time to time, any specimens of fossil plants, fishes, and shells which may be found at the pits under their charge may thus afford valuable aid.

"The Committee will be glad to hear from you, as to what help you can give, and will be pleased to receive suggestions in furtherance of their object."

Signed,

GEORGE B. HARRISON,	Members of the Joint Committee.
D. H. F. MATHEWS,	
W. BOYD DAWKINS,	
MARK STIRRUP,	
WILLIAM E. HOYLE,	
WILLIAM SAINT,	Hon. Secs.
GEORGE H. WINSTANLEY,	

N.B.—To ensure the best scientific results it is necessary that the fossils should be collected and preserved with care, and labelled with the locality, exact horizon or bed whence taken; noting their rarity or plenteousness, as well as any facts that are likely to be of interest to the geologist or palæontologist.

Mr. W. S. Barrett said: I have great pleasure in moving that the report be adopted; and in doing so I may say that I think there is a great deal in the report which is matter for congratulation. The papers named are, some of them, of very great interest to the geological and also to the mining world; and the Society, I have no doubt, feels greatly indebted to the gentlemen who gave so much time and trouble to the preparation of those papers. It is very satisfactory to learn from the report that there has been an influx of members during the past year and it will be more gratifying still if the number can be further increased. There is one matter of very great regret we cannot help mentioning—we are always sorry and grieved at the loss of members by death. One name is mentioned in the report which must appeal to those of us who have been members of the Society for any length of time. We all feel how sad the loss is of our friend Mr. Ormerod. I have been a member for very many years, and I have felt him to be a pillar—one of the ancient pillars I may say—of this Society; and when we lose such a member we should mark it, at any rate, with a passing word. With regard to our accounts, they are not less favourable than they were last year, and I trust they will be found even more favourable next year.

Mr. G. C. Greenwell, Jun., seconded the motion and the report was adopted—together with the Statement of Accounts presented by the Treasurer—unanimously.

ELECTION OF OFFICERS.

The President said the next business on the agenda was the election of officers and members of the Council for the coming session. The Council had met and considered a list of those whose names should be submitted to the meeting for

adoption. The first officer to be elected was the President for 1898-99.

Mr. MARK STIRRUP said: I beg to propose that Mr. Clegg Livesey, J.P., our present Treasurer, be elected President for the ensuing year. I think Mr. Livesey is known to most—certainly to the older—members of the Society; he is one of those "props" of whom Mr. Barrett has so well spoken, and in him we shall have a gentleman at our head whom everyone will respect. There will, I am sure, be no shortcoming on his part during his year of office.

Mr. RIDYARD: I have very great pleasure in seconding the proposition of Mr. Stirrup. I felt, myself, the honour of being appointed to this position last year, and I feel it doubly an honour when I can be succeeded by a gentleman like Mr. Clegg Livesey, whom I have known for many years as a gentleman practically connected with colliery working and an able geologist.

Mr. DICKINSON said he believed the Council had chosen the very best man for the position, and he was sure the meeting would elect him unanimously.

The proposition was then put to the meeting and carried unanimously.

Mr. DICKINSON proposed as Vice-Presidents Mr. John Gerrard, Mr. George Peace, Mr. Samson Garside, and Mr. D. H. F. Mathews.

The proposition was seconded by Mr. W. F. HOLROYD, and unanimously adopted.

Mr. STIRRUP in moving that Mr. Clegg Livesey, the newly-elected President, be re-appointed Honorary Treasurer of the Society, said: Mr. Livesey is already our esteemed Treasurer, and members will readily understand that it would be inconvenient as well as undesirable to make any change. In appointing him Honorary Treasurer, as well as President, we have a precedent in the case of our late lamented Treasurer, Mr. Ormerod, who during his presidential year held both offices.

Mr. DICKINSON: I have much pleasure in seconding that proposition.

The proposition was unanimously agreed to.

Mr. STIRRUP said: We have now to appoint two gentlemen to the important position of Honorary Secretaries. The Council recommend Mr. William Saint, H.M.I.M.,—already an Honorary Secretary—and with him Mr. C.R. Lindsey, B.Sc., in place of Mr. G. H. Winstanley, who wishes to retire. Mr. Winstanley, I should state, retires solely on account of his business engagements not admitting of his giving the necessary time to the duties of the Secretaryship.

The motion was seconded by Mr. G. C. GREENWELL, Jun., and unanimously passed.

Mr. RIDYARD: The Council have thought it well that some gentleman should be asked to take the post of Librarian, to arrange our valuable collection of books. Mr. Mark Stirrup was asked if he would undertake the duty, at least as a preliminary step, and I am pleased to say that he has consented to do so. We hope, in a few months, after they have been under his master hand, the treasures we possess on these shelves will be so arranged that any member will be able to find the book he wants without difficulty or loss of time. I propose the appointment of Mr. Stirrup.

The resolution was duly seconded by Mr. GEORGE PEACE, and carried unanimously.

Mr. DICKINSON: The members ought to be very much obliged to Mr. Stirrup for undertaking this duty. The Library needs re-arranging, and the work is such as few who are capable of doing it would undertake. The Council feel very much obliged to him indeed.

Mr. STIRRUP: I do not know whether I ought to thank the members for the position to which they have elected me; it is one that will involve very hard work, and which no other member seemed willing to undertake.

The following list of gentlemen, nominated as other members of the Council for the coming year, was next submitted to the meeting and unanimously adopted: Messrs. James Atherton, W. N. Atkinson, J. Barnes, W. S. Barrett, H. H. Bolton, jun., J. Crankshaw, G. B. Harrison, G. H. Hollingworth, W. F. Holroyd, S. S. Platt, G. H. Winstanley, H. A. Woodward.

The following Past-Presidents continue ex-officio members of the Council:—R. Clifford Smith, F.G.S., the Right Hon. the Earl of Crawford and Balcarres, Sir U. J. Kay-Shuttleworth, Bart., M.P., G. C. Greenwell, F.G.S., M.Inst.C.E., Edward Pilkington, J.P., Professor W. Boyd Dawkins, M.A., F.R.S., F.G.S., Joseph Dickinson, F.G.S., Henry Hall, H.M.I.M., John S. Burrows, F.G.S., James Tonge, F.G.S., Assoc.M.Inst.C.E., W. Saint, H.M.I.M., Robert Winstanley, C.E., W. Watts, F.G.S., Mark Stirrup, F.G.S., John Ridyard, F.G.S.

Messrs. George H. Hollingworth and H. A. Woodward were re-appointed Honorary Auditors.

Mr. Ridyard said: That, so far as the election of officers is concerned, concludes the business. I am reminded, however, by Mr. Clegg Livesey that, owing to the death of Mr. Ormerod, who was a Trustee of the Society along with himself, it will be necessary to appoint another gentleman to that position. It is the duty of the Trustees to take charge of the Society's investments, and to be responsible for the safe custody of all securities.

Mr. W. S. Barrett: I know no one who is better fitted to hold that position of responsibility than our friend Mr. Joseph Dickinson, one of our oldest and most respected members. I beg to move that he be appointed a Trustee in place of Mr. H. M. Ormerod deceased.

The motion was seconded and unanimously passed.

NEW MEMBERS.

The following gentlemen, who had been duly nominated, were balloted for and unanimously elected ordinary members of the Society :—

Mr. JOHN H. W. LAVERICK, Pye Hill House, Alfreton, Derbyshire.

Mr. GEORGE F. CLARK, Bickershaw Collieries, Leigh, Lancashire.

Mr. ERNEST DOUGLAS, Mining Engineer, Pemberton Collieries, Wigan.

VOTES OF THANKS.

Mr. CLEGG LIVESEY having taken the chair,

Mr. BURROWS proposed that the best thanks of the meeting be given to the retiring President, Mr. John Ridyard, for his conduct in the chair during the past year.

The motion was seconded by Mr. HOLROYD, and unanimously passed, amidst cheers.

Mr. RIDYARD briefly acknowledged the compliment.

The new PRESIDENT, Mr. Clegg Livesey, said: I wish to thank the members for having elected me as their President. It was with some diffidence that I accepted the position, knowing what the work is, and the amount of time it will take up; but some of the leading members of the Society have very kindly promised me all the help I may need. I feel very grateful to you, gentlemen, for your kindness.

Mr. ALFRED TONGE proposed and Mr. RIDYARD seconded a vote of thanks to the retiring members of the Council, which was unanimously passed.

EXHIBITION OF MINERALS, FOSSILS, AND FLINT IMPLEMENTS.

Attention was called to a series of collections on the tables, namely :—

A few polished specimens of Devonian and Carboniferous Coral Limestones, by Mr. Mark Stirrup.

A collection of flint implements (Neolithic) from the Yorkshire Moors, by Messrs. J. Barnes and W. F. Holroyd.

A collection of fossil fishes and reptiles, from the Jarrow Colliery, Co. Kilkenny, by Mr. Joseph Dobbs.

Clay ironstone nodules from the Lough Allen Coalfield, by Mr. Joseph Ryans.

Specimen of the "Cockle Shell Bed," from Chisnall Hall Colliery, by Mr. Owen Hughes.

A few specimens of French and Irish Bauxite, by Mr. William Saint.

Mr. Stirrup said: It may be well, before the meeting breaks up, that something should be said about the specimens here displayed. Mr. Saint has unfortunately been called away, or I have no doubt he would have said something with regard to those valuable specimens from the Jarrow Colliery, County Kilkenny, which he has been the means of procuring, and which have been given to the Society by one of our members, Mr. Dobbs. The Jarrow Colliery has, I may say, been noted for many years for its valuable remains of fishes and reptiles—remains, I believe, which have not been found so abundantly in any other part of the kingdom. It was expected that we should before this have had them in a proper state to present to the Owens College Museum,—

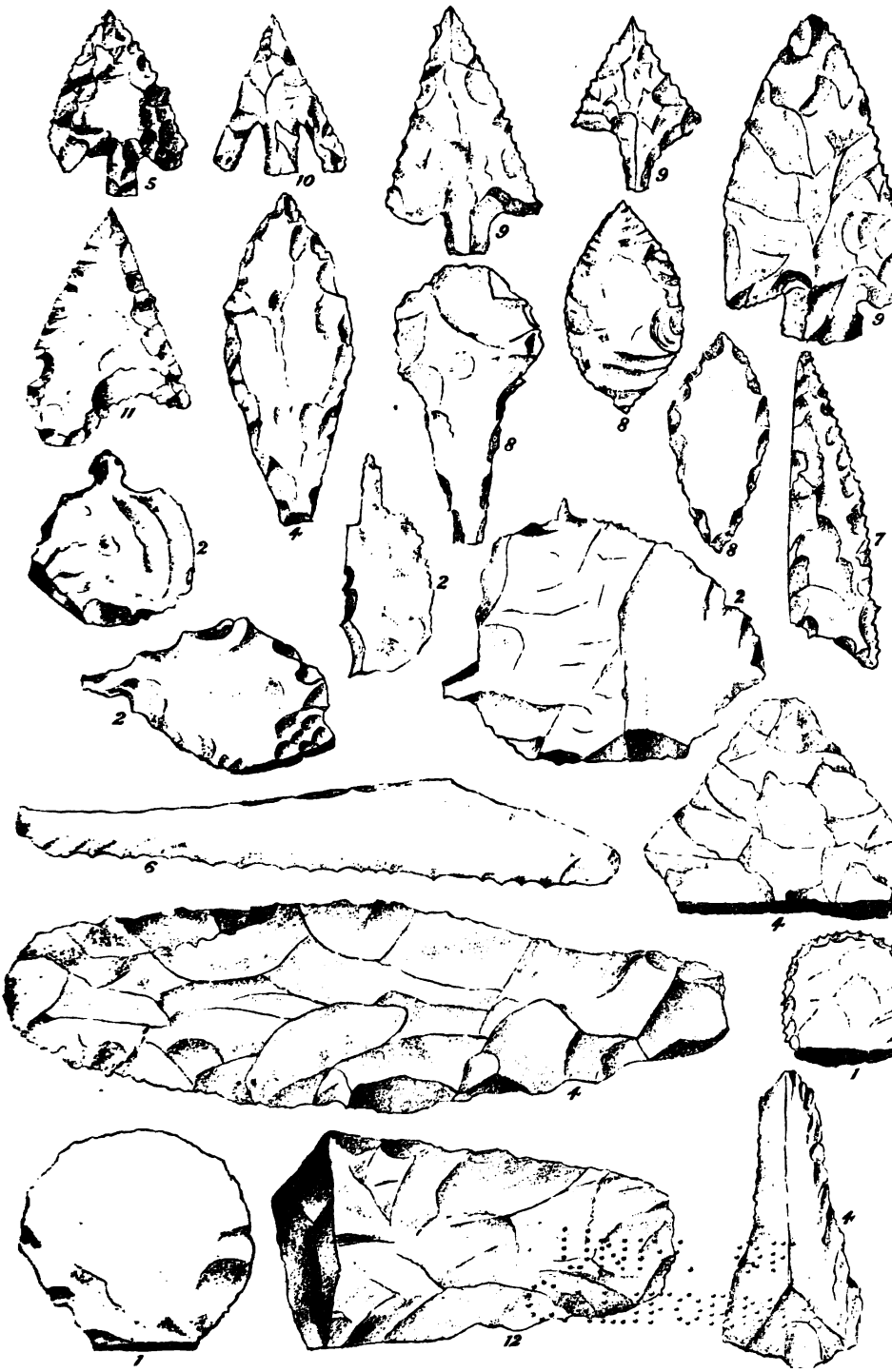
which I believe is to be their ultimate destination, for they are much too fine specimens to be in the hands of any private individual,—but no opportunity has yet been presented of having them accurately named. Mr. Saint some weeks ago placed them in my hands, and I wrote to the best authority I knew, a friend of my own, Mr. A. Smith Woodward, of the British Museum, who has promised me that he will, if possible, come down to Manchester towards the end of this month, and give his attention to the naming of these specimens. I think Mr. Smith Woodward will be doing the Society a great honour in naming these fossils and giving us his views thereon. They are worthy of being taken care of, and when they are consigned to the Museum they will be open to the inspection of everyone who takes an interest in these wonderful remains of a long past geological epoch. Mr. Stirrup also called attention to portions of the other collections, which were of special interest.

Mr. Holroyd, in describing the specimens of the Neolithic Flint Instruments from the Yorkshire Wolds, exhibited by Mr. Barnes and himself, said :—

The specimens exhibited by Mr. Barnes and myself comprise a series which are representative of the kind usually found on the Yorkshire Wolds, from Bridlington, northwards, to Saltburn. The specimens were obtained from the districts of Filey, Gauton, Hunmanby, and Wold Newton. They are usually remarkable for their small size, exquisite form, and varied outline, often imitating natural leaves, such as that of the willow tree, and may be classified under the following heads, viz. :—

1. Scrapers.
2. Borers or Awls.
3. Strike-a-lights.
4. Lance and Spear Heads.

Trans. Man. Geo. Soc. Part I. Vol. XXVI.
To illustrate Messrs Barnes & Holroyd's Notes on
Neolithic Flint Implements from the Yorkshire Wol



UNIV. OF
CALIFORNIA

5. Arrow Tips.
6. Knives, curved and straight.
7. Skinning-blades.
8. Leaf-shaped Implements.
9. Stemmed Arrow Heads.
10. Barbed Arrow Heads.
11. Arrow Heads with one tang.
12. A few Battle Axes of other kinds of stone, not flint, and ground at the edge for chisels or battle axes.

Most of the specimens are extremely delicate in outline, and illustrate well the great amount of care and skill which must have been bestowed upon them. (*See Plate I.*)

It is probable, judging from some of the specimens, that they were finished at the tip first, and that afterward the barbs and tang at the base were developed, as some of the specimens have only one barb, in others the tang is broken, and the implement has probably been rejected. There are also very curious triangular forms. None of these flint implements has been ground, but only chipped with great care. The curved knives are particularly interesting.

Other thick flints seem to have been used as chisels, and for chipping the more delicate arrow tips. All the flints exhibit the usual weathered appearance due to lying so long in the soil, and when broken by accident or design always show a much darker internal structure. The battle axes are in almost every case broken in two, and it is very difficult to obtain a whole one. The skin scrapers are mostly of a horse-shoe shape, with a blunt thick base, a clean face, produced at one stroke, on one side, and a chipped edge on the other. They vary in size from 1½-inches to ¾-inch in length; some few are kite-shaped, being broad at the top and attenuated below. They have all upon them more or less evidence of wear.

The leaf-patterned implements are extremely elegant and neat, some almost circular, others elliptical, while others again are spathulate.

An interesting discussion followed upon the modes of determining the authenticity of implements in general, and Mr. Holroyd showed that there were many interesting points of difference between the genuine flint implements and those made by that fabricator of spurious flint implements known by the name of "Flint Jack."

On the motion of Mr. DICKINSON the thanks of the meeting were accorded to the various exhibitors.

This concluded the business of the meeting.

LIST OF PAPERS AND SHORT COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE

SOCIETY DURING THE SESSION 1897-98.

1897.

November. Ridyard, John. "The Utility of Association for the promotion of Science, and of its application."

December. Greenwell, G. C. "On the Correlation of the Dover and Somersetshire Coalfields."

Caldwell, George. "Notes on Hematite found in the Maypole Sinking Pits."

1898.

January. Meachem, Frederick G. "Further Notes on Irruptions of Coal into the 'Thick Coal' Workings at Hamstead Colliery."

Tonge, James. "On the Patent Hydraulic Mining Cartridge."

Mathews, D. H. F. "On an Improved Appliance for Drawing Timber in Mines."

" (Special Meeting.) Dawkins, Prof. W. Boyd. "On Recent Additions to the Manchester Museum."

Hoyle, W. E. "Minerals from the Nickel Mines of Sudbury, Ontario."

Bolton, Herbert. "On the Nomenclature of the Seams of the Lancashire Lower Coal Measures."

February. Lloyd, Herbert. "On the Mineral Resources of the Middelburg District, Transvaal, South Africa."

Bigg-Wither, H. "Notes on Electrical Shot-firing."

Humphrey, Robert. "On the Occurrence of supposed Calcareous Tufa in the Interglacial Deposits of Blackpool."

Stirrup, Mark. "Report on the Recent International Geological Congress at St. Petersburg, with Sketch of the Geology of Finland."

March. Gresley, W. S. "On New Aspects of Coal-Bed Formation."

April. Ward, Thomas. "On the Rock Salt Deposits of Northwich, Cheshire, and the Result of their Exploitation." Part II.

May. Hall, Henry. "On the Coal Industry of the Rhenish-Westphalian Provinces."

Saint, William. "On an Improved Decking Table for facilitating the loading of Pit Cages."

June. Dickinson, Joseph. "Subsidence caused by Colliery Workings."

NEW ORDINARY MEMBERS.

Allen, Robert
Bennett, F. F.
Boden, Peter
Caldwell, J. S.
Dickinson, Archibald
Ellis, W. F. Wood
Evans, Walter
Glover, James W.
Guy, J. G.
Hall, William
Heather, Frank
James, Isaac
Keen, James
Krauss, John Samuel
Landless, Richard
Livesey, John
Lomax, James
Lowe, Henry
Naylor, Alfred
Nelson, J. William
Pickup, P. W. D.
Riston, W. A.
Roscoe, Thomas
Tickle, James
Walton, Thomas
Wells, Lionel B.
Widdowson, J. H.
Wood, John
Wood, Percy Lee
Woodeson, William

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Ormerod, H. M.

MEMBERS DECEASED.

Boole, George | Clark, Christopher F. | Heywood, James

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Dean, John
Greensmith, T.
Humphrey, Robert
Johnson, Alfred E.
Knowles, Robert
Laithwaite, Vincent
Lomax, Charles J.
Mawson, Robert Bryham
Moore, Alfred
Thompson, John G.
Warburton, Thomas

MEMBERS REMOVED FROM THE LIST.

Banks, William
Barlow, Sam. E.
Barton, Richard
Bradshaw, Edward
Clay, Richard
Clifford, William
Fallows, William
Fletcher, Thomas
Gascoyne, Rowland
Halliwell, James
Heyes, William A.
Howat, Andrew
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Knowles, James
Piggott, Isaiah
Robson, Thomas
Smith, Henry
Wells, Samuel B.

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PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-39-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-46-47	Moseley, Sir Oswald, Bart.
1847-48-49	Thicknesse, Ralph, M.P., Wigan.
1851-52-53	Black, James, M.D., F.G.S.
1853-54-55	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-61	Kay-Shuttleworth, Sir, J.P., Bart., M.P.,
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-64-65	Knowles, Andrew.
1867-8-9, 84-5	Greenwell, G. C., F.G.S., M.Inst.C.E.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3, 88-9	Knowles, John, M.Inst.C.E., J.P.
1873-74	Knowles, Thomas, M.P.
1874-5, 6-7, 86-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-76	Smith, R. Clifford, F.G.S.
1878-79	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-81	Kay-Shuttleworth, Sir Ughtred J., Bart., M.P.
1881-82	Gilroy, George, M.Inst.C.E.
1883-84	Pilkington, Edward, J.P.
1885-86	Ormerod, Henry Mere, F.G.S.
1889-90	Hall, Henry, H.M.I.M.
1890-91	Burrows, John S., F.G.S.
1891-92	Tonge, James, F.G.S., Assoc.M.Inst.C.E.
1892-93	Peace, Maskell William, F.G.S.
1893-94	Saint, William, H.M.I.M.
1894-95	Watts, William, F.G.S.
1895-96	Winstanley, Robert, C.E.
1896-97	Stirrup, Mark, F.G.S.
1897-98	Ridyard, John, F.G.S.

APPENDIX TO THE REPORT

ADDITIONS TO THE LIBRARY, 1897-8.

Barnsley.—Midland Institute of Mining, Civil, and Mechanical Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Belfast.—Natural History and Philosophical Society. Report and Proceedings for Session 1896-7. *From the Society.*

Birmingham.—South Staffordshire and East Worcestershire Institute of Mining Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Cambridge.—Museum. 32nd Annual Report Museums and Lecture Rooms' Syndicate for 1987; also Annual Report of the Library, 1897. *From the Woodwardian Museum.*

Cardiff.—Naturalists' Society. Vol. XXIX. *From the Society.*

Chesterfield and Midland Counties Institute of Engineers.—Transactions. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Cornwall.—Royal Geological Society. Transactions. Part 3, Vol. XII. *From the Society.*

Essex.—Journal of the Essex Field Club. Parts 5, 6, 7, 8, 9, Vol. X. *From the Club.*

Edinburgh.—Royal Geological Society. Transactions. Part 3, Vol. VII. *From the Society.*

Edinburgh.—Royal Society. Transactions. Vol. XXI. 1895-6, 1896-7. *From the Society.*

Edinburgh.—Royal Physical Society. Proceedings for the Session 1896-7. *From the Society.*

Glasgow.—Natural History Society. Part 1, Vol. V. *From the Society.*

Hamilton.—Mining Institute of Scotland. Transactions. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Hertford.—Natural History Society. Transactions. Parts 5, 6, 7, 8, 9, Vol. IX. *From the Society.*

Lancashire Coalfield.—Elias Hall's Geological Map. *From C. E. De Rance, F.G.S.*

Leeds.—Geological Association. Transactions. Part X. *From the Association.*

Leeds.—Yorkshire Geological and Polytechnic Society. Transactions. Part 13, Vol. III. *From the Society.*

Leeds.—Yorkshire Naturalists' Society. Transactions. Vol. XXI. *From the Society.*

Leicester.—Literary and Philosophical Society. Transactions. Parts 10, 11, 12, Vol. IV., New Series. *From the Society.*

London.—Royal Society. Proceedings. Parts 380-388, Vol. LXII., and Parts 389-401, Vol. LXIII. *From the Society.*

London.—Geological Society. Quarterly Journal. No. 212, Vol. LIII., and Nos. 213, 214, 215, Vol. LIV. *From the Society.*

London.—Geologists' Association. Proceedings. Parts 5, 6, 7, 8, 9, Vol. XV. *From the Association.*

London.—Geological Magazine. Nos. 11-12 (New Series), Vol. IV., and Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, Vol. V. *Purchased.*

London.—Palaeontographical Society. Volume for 1897. *Purchased.*

London.—Iron and Steel Institute. Journal. Part 2, Vol. LII., and Part 1, Vol. LIII. *From the Institute.*

London.—Royal Institution of Great Britain. Proceedings. Part 2, Vol. XV. *From the Institution.*

London.—The Mining Journal. No. 3245, Vol. LXVII., to No. 3296, Vol. LXVIII.

London.—The Colliery Guardian. No. 1923, Vol. LXXIV., to 1974, Vol. LXXVI.

London.—Iron and Coal Trades Review. Nos 1548, Vol. LV., to 1599, Vol. LVII.

Manchester.—Literary and Philosophical Society. Memoirs and Proceedings. Parts 3-4, Vol. XLII. *From the Society.*

Manchester.—Geographical Society. Journal. Nos. 10-12, Vol. XII.; Nos. 1-3, 7-9, 10-12, Vol. XIII.; and Nos. 1-6, Vol. XIV. *From the Society.*

Manchester.—Field Naturalists' Society. Report and Proceedings for 1897. *From the Society.*

Manchester.—The Owens College Museum. Report for the year 1897-8; also Catalogue of the Hadfield collection of shells from the Loyalty Islands. *From the College.*

Newcastle-upon-Tyne.—Institution of Mining Engineers. Part 3-4, Vol. XIII.; Parts 1, 2, 3, 4, 5, Vol. XIV.; Parts 1, 2, 3, 4, Vol. XVI. *From the Institution.*

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers. Transactions. Included in the Transactions of the Institution of Mining Engineers; also Annual Report, and "Account of the Strata of Northumberland and Durham." *From the Institution.*

Salford.—Annual Report of the Museum, Libraries, and Parks Committee, 1896-97.

Stafford.—North Staffordshire Field Club. Vol. XXXII., 1897-8. *From the Club.*

Stoke-on-Trent.—North Staffordshire Institute of Mining and Mechanical Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Swansea.—South Wales Institute of Engineers. Proceedings. Parts 6, 7, 8, Vol. XX.; and Part 1, Vol. XXI. *From the Institute.*

Truro.—Royal Institution of Cornwall. Transactions. Parts 2-3, Vol. XIII. *From the Institution.*

Wigan.—Science and Art of Mining. Nos. 5 to 26, Vol. VIII.; and Nos. 1, 2, 3, 4, Vol. IX.

Pamphlets and Reports.—English and Foreign.

Mineral Statistics of the Mines and Quarries for 1897; Annual Report for S.W. District; also H.M. Inspector's Report of Mines and Quarries, 1897. London. *Presented by Joseph S. Martin.*

A large number of valuable pamphlets relating to Geological subjects. *Through Mr. W. Whitaker, F.R.S.*

INDIA.

Calcutta.—Records of the Geological Survey of India. Part 4, Vol. XXX. *From the Governor General in Council.*.

AUSTRALIA.

Adelaide.—Royal Society of South Australia. Transactions. Part 2, Vol. XXI.; also Part 1, Vol. XXII. *From the Society.*

Sydney.—The Australian Mining Standard: A record of Mining, Financial. and Engineering Progress, Nos. 463-471, 473-474, 476-480, 491-495, 498-507, 511. *From the Editor.*

Sydney.—Geological Survey of New South Wales: Department of Mines. Records, Part 4, Vol. V. *From the Hon. the Minister of Mines.*

Sydney.—Royal Society of New South Wales. Journal and Proceedings, Vol. XXXI, 1897.

Sydney.—Australian Association for the Advancement of Science. Vol. I. *From the Association.*

Sydney.—Institution of Mining Engineers. Proceedings, 1898.

CANADA.

Halifax, N.S.—Nova Scotian Institute of Science. Proceedings and Transactions. Part 3, Vol IX., 2nd Series. *From the Institute.*

Hamilton.—Hamilton Association. Journal and Proceedings for 1897-8. *From the Association.*

Ottawa.—Canadian Mining Review. Nos. 10-12, Vol. XVI.; and Nos. 1-7, Vol. XVII. *From the Editor.*

Ottawa.—Geological and Natural History Survey of Canada. Part 3, Vol. III. *From the Director of the Survey.*

St. John, New Brunswick.—Natural History Society of New Brunswick. Bulletin 16. *From the Society.*

Toronto.—Canadian Institute. Transactions. Parts 2, 4, 5, Vol. I. (New Series). *From the Institute.*

U.S. AMERICA.

Baltimore.—Maryland Geological Survey, Vol. I. *From the State Geologist.*

Cambridge.—Harvard College. Bulletin of the Museum of Comparative Zoology. Nos. 1, 2, 3, 4, 5, 6, 7, Vol. XXXI.; and Nos. 1, 2, 3, 4, 5, 6, 7, 8, Vol. XXXII. *From Alex. Agassiz.*

Chapel Hill, No. Carolina.—The Elisha Mitchell Scientific Society. Nos. 1, 2, Vol. XIV.

Chicago.—Field Columbian Museum. Parts 1-9, Vol. XXVI. and Parts 1-10, Vol. XXVII. *From the Museum.*

Denver.—Colorado Scientific Society. Proceedings and Pamphlets. *From the Society.*

Indiana.—Department of Geological and Natural Resources. Annual Report.

Iowa.—Geological Survey of. Vols. VI. and VII. *From the Director of the Survey.*

Madison.—Wisconsin Academy. Reports, 1896-7.

Minneapolis.—The American Geologist. Nos. 4, 5, 6, Vol. XX.; Nos. 1, 2, 3, 4, 5, 6, Vol. XXI.; and Nos. 1 and 2, Vol. XXII. *Purchased.*

Minneapolis.—The American Geologist. Vols. I. to XI. Bound. *Through Mr. W. Whitaker, F.R.S.*

New York.—The American Museum of Natural History. Bulletin, Vol. IX.; also Annual Report for 1897. *From the Museum.*

Philadelphia.—Franklin Institute. Journal. Nos. 863 and 864, Vol. CXLIV.; Nos. 1, 2, 3, 4, 5, 6, Vol. CXLV.; and Nos. 1, 2, 3, Vol. CXLVI. *From the Institute.*

Philadelphia.—Academy of Natural Sciences. Proceedings. Parts 2 and 3, 1897-8. *From the Academy.*

Rochester.—Geol. Soc. of America. Vols. I., II., III. Bound. *Through Mr. W. Whitaker, F.R.S.*

Scranton, Pa.—Mines and Minerals. Journal. Nos. 3-12. Vol. XVIII.; and Nos. 1 and 2, Vol. XIX. *From the Editor.*

Washington.—Smithsonian Institute. Reports of the U.S. State Museum, 1895.

Washington.—Geological Survey of Mineral Resources of the United States.

Washington.—Atlas to accompany Monograph XXVIII. of the Marquette Iron-bearing District, 1896.

FOREIGN.

Berlin.—Gesellschaft für Erdkunde: Zeitschrift, Nos. 4, 5, 6, Vol. XXXII.; Nos. 2, 3, Vol. XXXIII.; Verhandlungen, Nos. 8, 9, 10, Vol. XXIV.; Nos. 1, 5, 6, Vol. XXV. *From the Society.*

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft. Parts 2, 3, 4, Vol. XLVIII.; Part 3, Vol. XLIX.; Part 1, Vol. L. *From the Society.*

Brussels.—Société Royale Malacologique de Belgique. Annales 1893-4-5-6. *From the Society.*

Caen.—Société Geologique du Nord (5th Series), Vol. I. *From the Society.*

Christiania.—Archiv Mathematik og Naturvidenskab. Part 4. Vol. XIX.; Parts 1, 2, Vol. XX.

Freiburg.—Naturforschenden Gesellschaft of Freiburg. Parts 1, 2, 3, Vol. X.

Halle, A/S.—Mittheilungen des Vereins für Erdkunde. 1897. *From the Society.*

Helsingfors.—Commission de la Geologique de la Finlande. Parts 1, 2, 3. 4, 5, 6, Vol. I. *From the Director.*

Kieff (Russia).—La Société des Naturalistes. Memoires, 1896-7-8.

Lille.—Société Géologique du Nord. Annales, Vol. XXIV., 1896, and Vol. XXV., 1897.

Mexico.—Sociedad Cientifica "Antonio Alzate." Memorias Y. Revista. Nos. 5, 6, 7, 8, 9, 10, 11, 12, Vol. X.; Nos. 1, 2, 3, 4, Vol. XI.

Naples.—Rendiconti dell' Accademie Scienze Fisiche e Mathematiche. Nos. 1, 2, 3, 4, 5, 6, 3rd Series, Vol. IV. *From the Academy.*

Paris.—Société de Spéléogique. Bulletin. No. 2, Vol. III. *From the Society.*

Rome.—Atti della Reale Accademia dei Lincei Rendiconti. Nos. 9, 10, 11, 12, Vol. VI.; and 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, Vol. VII. *From the Academy.*

St. Petersburg.—Comité Geologique. Bulletin. Nos. 3, 4, 5, 6, 7, 8, 9, Vol. XVI.; also Supplement to Vol. XVI. *From the Society.*

St. Petersburg.—L'Académie Impériale des Sciences. Bulletin, V. Series, Nos. 2, 3, 4, 5, Vol. VII.; Nos. 1, 2, 3, 4. Vol. VIII. *From the Academy.*

Vienna.—K. K. Naturhistorischen Hofmuseums. Annalen. No. 1, Vol. XI. *From the Museum.*

SOCIETIES WITH WHICH THE SOCIETY EXCHANGES ITS TRANSACTIONS, AND INSTITUTIONS AND JOURNALS TO WHICH A COPY IS SENT FREE.

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Institute of Mechanical Engineers, Victoria Street, S.W.

Iron and Steel Institute, Victoria Mansions, S.W.

Royal Institution of Great Britain.

Royal Society, Burlington House, W.

Public Library, Kensington, High Street, W.

Manchester .....The Manchester Association of Engineers, Grand Hotel, Aytoun Street.

Field Naturalists' Society, 16, Kennedy Street.

Free Library, King Street.

Literary and Philosophical Society, 36, George Street.

Manchester Geographical Society, 16, St. Mary's Parsonage.

The Owens College.

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South Staffordshire and East Worcestershire Institute of Mining Engineers, Colmore Chambers, 3, Newhall Street.

Bradford .....Public Free Library, Bradford, Yorkshire.

Bristol ..... Naturalists' Society, Clifton.

Cambridge .....Geological Museum, University.
University Library.

Cardiff ....Naturalists' Society, 44, Loudoun Square.
South Wales Institute of Mining and Mechanical Engineers, Park Place, Cardiff.

Chester .....Society of Natural Science, Grosvenor Museum.

Chesterfield.....Chesterfield and Midland Counties Institution of Mining Engineers, 13, Cavendish Street.

Cornwall .....Royal Geological Society, Penzance.
Royal Institution, Truro.
Mining Association and Institute of Cornwall, Tuckingmill, Camborne.

Essex .....Essex Field Club, Chelmsford, Essex.

Exeter .....Albert Memorial Museum.

Leeds .....Philosophical and Literary Society.
Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Hon. Librarian, 259, Hyde Park Road, Leeds).
Geological Association, Mechanics' Institution, Cookridge Street.

Leicester.....Literary and Philosophical Society.

Liverpool .....Free Library and Museum.
Geological Association, Free Library, William Brown Street.
Geological Society, Royal Institution.
Science Students' Association, Royal Institution, Colquitt Street.

Mirfield .....Geological and Polytechnic Society of Yorkshire, Hoptown, Mirfield.

Newcastle-on-Tyne Institution of Mining Engineers.
North of England Institute of Mining and Mechanical Engineers.

Newcastle-under-Lyme ..... North Staffordshire Naturalists' Field Club. (W. Wells Bladen, Esq., Stone, Staffordshire).

Norwich .....Norfolk and Norwich Naturalists' Society.

Oxford .....Bodleian Library.
Radcliffe Library.

North Shields....Public Free Library.

Rochdale.....Literary and Scientific Society, 105, Freehold Street.

Southampton ....Hampshire Field Club, Harley Institution.

Stoke-on-Trent ..North Staffordshire Institute of Mining and Mechanical Engineers.

Warwick.....Natural History Society.

Watford, Herts ..Hertfordshire Natural History Society and Field Club, the Public Library, Watford. (Daniel Hill, Esq., Hon. Librarian, Herga, Watford, Herts).

Wigan .....Free Library.
Mining School.

II.—Scotland.

Dundee .....Free Library and Museum.

Edinburgh .... .Advocates' Library.
Geological Society.
Royal Society.
Royal Physical Society.

Glasgow .....Geological Society.
Natural History Society.

Hamilton .....Mining Institute of Scotland.

III.—Ireland.

Dublin .....Royal Dublin Society.
Trinity College Library.

Belfast .....Natural History Society, the Museum.

IV.—Australia.

Adelaide .....Royal Society of South Australia (W. C. Rigby, 74, King William Street, Adelaide).

Melbourne .....Geological Society of Australasia, 17A, Queen Street.
Public Library of Victoria.

Sydney .....Free Public Library.
Royal Society of New South Wales, 37, Elizabeth Street.
Department of Mines.—The Honourable the Minister of Mines.
Australian Mining Standard, 108, Pitt Street.

V.—Canada.

Halifax, Nova Scotia..... } Nova Scotian Institute of Natural Science.

Hamilton .....Hamilton Association.

Montreal.....Library of Canadian Mining Institute, Room 4, Windsor Hotel, Montreal.
M'Gill University (Principal, Sir J. W. Dawson, F.G.S.).

Ottawa .....Geological and Natural History Survey of Canada (C. M. Dawson, C.M.G., Director, Museum, Sussex Street, Ottawa).

St. John's, N.B...Natural History Society of New Brunswick.

Toronto .....Canadian Institute.

VI.—India.

Calcutta .....Geological Survey of India.

VII.—United States.

Boston .....Free Library.

Chapel Hill, North Carolina ..... } The Elisha Mitchell Scientific Society.

Columbus .....Ohio, Geological Survey of. (The State Geologist).

Denver .....Colorado Scientific Society, Denver, Colorado.

Indiana .....Department of Geology and Natural Resources (W. S. Blatchley, Esq., State Geologist).

Illinois .....Illinois Mining Institute, Springfield, Ill.
Field Columbian Museum, Chicago.

Michigan .....Michigan Mining School, Houghton.

Newhaven .....Professor O. C. Marsh, F.G.S.

New York .....American Institute of Mining Engineers (R. W. Raymond, Box 223, New York City).

New York .....American Museum of Natural History, Central Park.

Philadelphia ....Academy of Natural Sciences.
Franklin Institute.
Pennsylvania Geological Survey.
American Philosophical Society, 104, S. Fifth Street.

Scranton, Pa.....Editor of Mines and Minerals.

Washington ....Department of the Interior. U.S. Geological Survey.
Smithsonian Institution.

Wisconsin .....Wisconsin Academy of Science, Arts, and Letters, Madison.

Wyoming .....Historical and Geological Society.

VIII.—Foreign Societies.

Berlin .....Deutsche Geologische Gesellschaft.
Gesellschaft für Erdkunde. Zimmerstrasse, 90, Berlin, S.W., 12.

Brussels .....Société Royale Malacologique de Belgique.

Buenos Ayres....Officiana Nacional de Commercie.

Caen .....Société Geologique du Nord.

Christiania.....Royal University of Norway.

Dresden .....Naturwissenschaftliche Gesellschaft Isis.

Halle, A/S. ....Verein für Erdkunde.
Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.

Helsingfors.....Geological Commission of Finland. Dr. J. J. Sederholm.

Kazan, Russia ..La Société des Naturalistes de l'Université de Kazan.

Kieff, Russia ....La Société des Naturalistes.

Lausanne (*Suisse*).Société Vaudoise des Sciences Naturelles.

Naples .....Royal Academy of Sciences, Bibliothèque de l'Université de Naples.

Pisa .....Società Toscana di Scienze Naturali, Museo di Storia-Naturale.

Rio de Janeiro ..Museo Nacional.

Rome .....Reale Academia dei Lincei.

St. Petersburg ..Académie Impériale des Sciences.
Institut des Mines. Comité Géologique.

Turin .....Acadêmie Royale des Sciences.

IX.—Scientific Journals, &c.

Iron and Coal Trades Review, 342, Strand, W.C.

Mining Journal, 18, Finch Lane, London.

Colliery Guardian, 49, Essex Street, Strand, London.

Science and Art of Mining, 27, Wallgate, Wigan.

LIST OF MEMBERS.

NOVEMBER, 1898.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	Names and Addresses.
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1884	Ainsworth, John, Colliery Offices, Walkden, Bolton.
1884	Aldred, James, Bull Hotel, Radcliffe.
1897	Allen, Edward, M.E., Willow Bank, Peel Causeway, Bowdon, Cheshire.
1898	Allen, Robert, 46, Norah Street, Lower Broughton, Manchester.
1879	Arrandale, John Thomas, 82, Brook House Street, Wigan.
1893	Ashworth, John, C.E., 8, King Street, Manchester.
1878	Ashworth, Thomas, 42, Deansgate, Manchester.
1877	Atherton, James, 13, Mawdsley Street, Bolton. *Member of Council.*
1895	Atherton, H. Stanley, Land and Mine Surveyor, 13, Mawdsley Street, Bolton.
1878	Atkinson, W. N., H.M. Inspector of Mines, Barlaston, Stoke-on-Trent. *Member of Council.*
1897	Baker, Godfrey, Pendlebury, Manchester.
1893	Bancroft, Robert E., 8, St. James's Square, Manchester.
1895	Barnes, J., F.G.S., 1, Trafalgar Street, Lower Broughton. *Member of Council.*
1875	Barrett, W. S., 64, The Albany, Old Hall Street, Liverpool.
1891	*Bell, Thomas*, J.P., Valley Road, Scarborough.
1897	Bennett, F. F., M.I.E.E., 13, Victoria Buildings, Manchester.
1881	Black, W. G., F.R.C.S. Ed., F.G.S. Ed., 2, George's Square, Edinburgh.

Year of Election.	Names and Addresses.
1898	Boden, Peter, Butterworth Hall Colliery, Milnrow, Rochdale.
1889	Bolton, Edgar O., Burnley Collieries, Burnley.
1867	Bolton, H. H., Newchurch in Rossendale, near Manchester.
1880	Bolton, H. H., jun., The Collieries, Accrington. *Member of Council.*
1894	Borrows, William, Engineer, Providence Foundry, St. Helens.
1878	Bradford, The Right Hon. the Earl of, Bradford Estate Office, Bolton (G. R. Carter, Esq., Agent).
1878	Bramall, Ernest E., Pendlebury Collieries, near Manchester.
1886	Bramall, Henry, M Inst.C.E., Shade House, Pendlebury, Manchester.
1895	Brierley, Brandon T., Bellayre, Lymm, Cheshire.
1878	Brocklehurst, Thomas, Rumworth Colliery, Dean, Bolton.
1877	*Broeck, Ernest Van den,* 39, Place de l'Industrie, Brussels.
1877	*Brongniart, Charles,* F.E.S., 9, Rue Linné, Paris.
1897	Brooks, The Hon. William, J.P., Crawshaw Hall, Rawtenstall, Manchester.
1881	Bryham, William, Douglas Bank Colliery, Wigan.
1878	Burrows, John S., F.G.S., Green Hall, Atherton, near Manchester. *Past-President.*
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1897	Caldwell, J. S., Westhoughton, Bolton.
1884	Campbell, H. H., Surveyor, Hardshaw Street, St. Helens.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1898	Clark, Geo. F., Bickershaw Collieries, Leigh, Lancashire.
1894	Clarke, Robert, 42, Deansgate, Manchester.
1894	Cole, Robert H., Endon, Stoke-on-Trent.
1895	Coope, Samuel, Land and Mine Surveyor, Farnworth, Bolton.
1878	Cowburn, Henry, 253, Westleigh Lane, Westleigh, near Manchester.
1883	Crankshaw, Joseph, Montcliffe, Horwich. *Member of Council.*

Year of Election.	Names and Addresses.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1862	Cross, John, 77, King Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S., F.S.A., The Owens College, Manchester. *Past-President.*
1877	*De Rance, C. E.*, F.G.S., 91, Palatine Road, Blackpool.
1898	Dickinson, Archibald, Bank Hall Colliery, Burnley.
1856	Dickinson, Joseph, F.G.S., South Bank, Pendleton. *Past-President.*
1889	Dobbs, Joseph, Coolbawn, Castlecomer, Co. Kilkenny.
1898	Douglas, Ernest, Pemberton Collieries, Wigan.
1898	*Eagle, George, 77, King Street, Manchester.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1895	Ellis, Thomas Ratcliffe, Solicitor, King Street, Wigan.
1897	Ellis, W. F. Wood, M.Inst.M.E., M.S.A., 5, John Dalton Street, Manchester.
1884	Else, George, Altham Colliery, Whalley Road, Accrington.
1895	Evans, Robert, Mining Engineer, Royton, Oldham.
1897	Evans, Walter, J.P., M.E., Royton, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1891	Finch, John, Hamstead Colliery, Great Barr, Birmingham.
1891	Fletcher, Arthur, Outwood Collieries, Radcliffe.
1896	Fletcher, Leonard R., Atherton Collieries, Atherton, Manchester.
1896	Fletcher, Norman, The Hollins, Bolton.
1889	Foster, John W., 6, North Street, New Silksworth, Sunderland.
1873	Garforth, W. E., F.G.S., Halesfield, Normanton.

Year of Election.	Names and Addresses.
1893	Garside, Edward, B.Sc., Town Hall Chambers, Ashton-under-Lyne.
1884	Garside, Samson, Denton and Haughton Collieries, Denton, *Vice-President.*
1874	*Geikie, Sir Archibald*, D.Sc., LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1892	Gerrard, John, H.M. Inspector of Mines, Worsley. *Vice-President.*
1882	Glover, B. B., 41A, Victoria Buildings, Manchester.
1898	Glover, J. W., M.E., 41A, Victoria Buildings, Manchester.
1892	Grant, Frederick John, Bank Field, Burnley.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester,
1863	Greenwell, G. C., F.G.S., M.I.C.E., Elm Tree Lodge, Duffield, Derby. *Past-President.*
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport.
1879	Greenwood, John, c/o The Globe Spinning Company, 1, Marsden Street, Manchester.
1892	Gregson, G. Ernest, 11, Chapel Street, Preston.
1890	Gresley, W. S., F.G.S., F.G.S.A., 348, West 8th Street, Erie, Pennsylvania, U.S.A.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1888	Grundy, James, Inspector of Mines in India, 27, Chowringhee Road, Calcutta, India.
1897	Guy, J. G., Hindley Green Colliery, Abram, Wigan.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot, *Past-President.*
1897	Hall, William, B.Sc., Science Teacher, 44, Arrowsmith Terrace, Bolton.
1887	Hallas, George H., Mining Engineer, Huyton, near Liverpool.
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1897	Harris, George E., M.E.. Assam Railway and Trading Co., Limited, Margerita, Assam, India.

Year of Election.	Names and Addresses.
1894	Harrison, George B., H.M. Inspector of Mines, 278, Brooklands Terrace, Worsley Road, Swinton, Manchester. *Member of Council.*
1892	*Haworth, Denis, Beech House, Blackburn Road, Accrington.
1894	Hayward, John, Ladyshore Colliery, Little Lever, Bolton.
1897	Heather, Frank, 35, Dickinson Street, Manchester.
1889	Higson, Charles H., The Park Collieries, Wigan.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1897	Hobson, Bernard, M.Sc., F.G.S., The Owens College, Manchester.
1877	Holding, William, Cossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., 12, King Street, Manchester. *Member of Council. Honorary Auditor.*
1895	Holroyd, W. F., F.G.S , River Cottage, Lower Broughton, *Member of Council.*
1897	Howsin, Evelin G., Huntroyd Estate Office, Padiham.
1884	Hughes, Owen, The Grange, Coppull, near Chorley.
1874	*Hull, Professor Edward,* M.A., F.R.S., 20, Arundel Gardens, Notting Hill, London, W.
1895	Hutchinson, John William, Bamfurlong Collieries, Wigan.
1889	Iles, John, 76, Church Street, South Shore, Blackpool.
1887	Jackson, Andrew, Manager, Collins Green and Bold Collieries, Newton-le-Willows.
1878	Jackson, Charles G., Rookwood, near Chorley.
1898	James, Isaac, Wigan Junction Collieries, Abram, Wigan.
1883	Jobling, Albert, Spring Wood House, Burnley.
1883	Jobling, Henry, Spring Wood House, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1882	Johnson, William, Abram Colliery, Wigan.

Year of Election.	Names and Addresses.
1887	Kay-Shuttleworth, Sir Ughtred J., Bart., M.P., Gawthorpe Hall, Burnley. *Past-President.*
1897	Keen, James, Hindley Green, Wigan.
1897	Keirby, John E., Swinton, Manchester.
1894	Kelsall, James E., High Bank, Tonge, Bolton.
1893	Kendrick, James P., 8, St. James's Square, Manchester.
1879	*Kinahan, G. H.*, M.R.I.A., Woodlands, Fairview, Co. Dublin.
1889	Knowles, John, Brynn Mount, Westwood, Lower Ince, Wigan.
1887	*Knowles, Lees, M.A., LL.M., M.P., Westwood, Pendlebury.
1898	Krauss, John Samuel, B.A., Whitecot, Wimslow, Cheshire.
1898	Landless, Richard, Bank Hall Colliery, Burnley.
1898	Laverick, John H. W., Pye Hill House, Alfreton, Derbyshire.
1890	Law, J. Illingworth, Waterfoot, near Manchester.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.
1897	Lees, Frederick, The Rookery, Ashford, Bakewell.
1894	Lindsey, Charles R., B.Sc., 509, Edge Lane, Droylsden, Manchester. *Hon. Secretary.*
1862	Livesey, Clegg, J.P., Bradford Colliery, Manchester. *President and Hon. Treasurer.*
1898	Livesey, John, 117, Stoneclough Road, Stoneclough, Manchester.
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1898	Lomax, James, 65, Starcliffe Street, Moses Gate, Bolton.
1877	Lord, James, Hill House, Rochdale.
1898	Lowe, Henry, Limehurst Colliery, Limehurst, Ashton-under-Lyne.
1881	McAlpine, G. W., Parkside, Accrington.
1897	McCallam, Theo. S., C.E., 4, Chapel Walks, Manchester.
1890	McGeevor, James, Garswood Hall Colliery, Wigan.

Year of Election.	Names and Addresses.
1897	Makepeace, H. R., H.M. Inspector of Mines, Newcastle-under-Lyme.
1891	Marshall, Herbert S., The Larches, Wigan.
1892	Mathews, D. H. F., H.M. Inspector of Mines, Hoole, Chester. *Vice-President.*
1893	Matthews, E. L., Mechanical Engineer, &c., Imperial Iron Works, West Gorton, Manchester.
1896	Matthews, Thomas, Artesian Engineer, West Gorton, Manchester.
1873	*Martin, Joseph S.*, H.M. Inspector of Mines, Durdham Park, Clifton, Bristol.
1890	Mercier, Maunsell, The Cliff, Higher Broughton, Manchester.
1892	Miller, Arthur, Broad Oak, Hurst, Ashton-under-Lyne.
1892	Millington, W. W., Hardman House, Hollinwood, Oldham.
1892	Mills, David, Bradford Street, Farnworth.
1895	Mitton, A. Dury, Oakwood, Walkden, Bolton.
1892	Morris, Moses, Swan Lane, Hindley, Wigan.
1895	Mort, Arthur, B.Sc., 345, Ashton New Road, Clayton, Manchester.
1874	*Morton, G. H.*, F.G.S., 209, Edge Lane, Liverpool.
1888	Munro, Donald, Fairfield, near Manchester.
1878	Nall, Simon, Newbold, Rochdale.
1898	Naylor, Alfred, Cotes Park Colliery, Alfreton, Derbyshire.
1897	Nelson, William, jun., Clifton and Kersley Collieries, Clifton, Manchester.
1897	Noar, L. Lamb, The Grove, Lymm.
1888	Oliver, Samuel A., King Street, Wigan.
1891	Orchard, Albert J. A., Whitehouse, Nailstown Colliery, near Leicester.

Year of Election.	Names and Addresses.
1876	Peace, George, Monton Grange, Eccles. *Vice-President.*
1883	Peace, George Henry, M.Inst.C.E., Monton Grange, Eccles.
1897	Pearce, Charles H., Surveyor, Hulton Collieries, near Bolton.
1897	Pickup, P. W. D., Rishton Colliery, Rishton, near Blackburn.
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1887	Platt, Samuel Sydney, M.Inst.C.E., F.G.S , Moss House, Kings Road, Rochdale. *Member of Council.*
1891	Prestwich, Joseph.
1895	Purdy, Richard, Moston Colliery, Newton Heath, Manchester.
1897	Reid, Alexander, Dover Collieries, Dover.
1897	Richardson, Isaiah, Blainscough Collieries, Coppull, near Chorley.
1860	Ridyard, John, F.G.S , Hilton Bank, Little Hulton, Bolton. *Past-President.*
1893	Rigby, John, Highfield, Winsford, Cheshire.
1897	Ritson, W. A., Crumpsall, Manchester.
1889	Robinson, John, Haydock Collieries, St. Helen's.
1892	Roscoe, George, Peel Hall Collieries, Little Hulton, Bolton.
1898	Roscoe, Thomas, Peel Hall Collieries, Little Hulton, Bolton.
1895	Rothwell, Samuel, Silverwell Street, Bolton.
1895	Ryans, Joseph, Colliery Manager, Arigna Mines, Carrick-on-Shannon.
1887	Saint, William, H.M. Inspector of Mines, Kersal Bank Higher Broughton, Manchester. *Past-President. Hon. Secretary.*

Year of Election.	Names and Addresses.
1888	Scarborough, George Edward, Colliery Manager, Newtown and Meadows Collieries, Wigan.
1897	Scholes, Thomas, 25, Crossley Street, Longsight, Oldham.
1887	Scott, Frederick W., Atlas Works, Reddish, near Stockport.
1889	Scott, William B., 133, Manchester Old Road, Middleton.
1891	Scowcroft, Thomas, Redthorpe, Tonge, Bolton.
1882	Settle, Joel, The Hill, Alsager, Stoke-on-Trent.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1889	Settle, William, Brunswick House, Haulgh, Bolton.
1884	Shaw, David, Norbury Moor, near Stockport.
1884	*Simpson, W. W., Winkley, near Whalley, Blackburn.
1894	Slee, John, Engineer, Earlestown.
1864	*Smethurst, William, F.G.S.
1881	Smith, John, Bickershaw Collieries, Westleigh, near Manchester.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney Arthur, 1, Princess Street, Albert Square, Manchester.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire.
1881	Squire, J. B., Assoc.M.Inst.C.E., The Wynd, Streatham Park, London, S.W.
1890	Stafford, Thomas, 1, Lea Road, Heaton Chapel, Stockport.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon. *Past-President. Hon. Librarian.*
1882	Stopford, T. R., Ashton's Green Collieries, St. Helens, Lancashire.
1891	Sutcliffe, Richard, Horbury, near Wakefield.
1889	Taylor, William, 6, Bull Hill, Darwen.
1892	Thom, John, Canal Works, Patricroft.
1893	Thompson, F. W., 5, Wood Street, Bolton.
1892	Thompson, James, Westhoughton, Bolton.

Year of Election.	Names and Addresses.
1893	Thompson, Peter, 40, Hardman Street, Hollinwood, Oldham.
1897	Tickle, James, Abram Collieries, Bickershaw, Wigan.
1893	Timmins, Arthur, A.M.I.C.E., F.G.S., Bridgewater Foundry, Runcorn.
1891	Tonge, Alfred J., Hulton Colliery, near Bolton.
1873	Tonge, James, F.G.S., Assoc.M.Inst.C.E., Albany Chambers, Mawdsley Street, Bolton. *Past-President.*
1898	Tonge, James, Jun., 21, Mawdsley Street, Bolton.
1886	*Trafford, Sir Humphrey Francis de, Bart., 18, Arlington Street, London, W.
1895	Travers, T. W., Mining Engineer, Church Street, Leigh, Lancashire.
1892	Turner, William, Wigan Junction Colliery, Abram, near Wigan.
1896	Turner, William, Sherdley Collieries, St. Helens.
1876	Unsworth, John, Scott Lane Collieries, Wigan.
1887	Walkden, Richard, Colliery Manager, 26, Watery Lane Terrace, Springvale, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1893	Wallwork, Jesse, Shakerley Collieries, Tyldesley, near Manchester.
1888	*Walmsley, Oswald, 2, Stone Buildings, Lincoln's Inn, London.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1897	Walton, Thomas, Habergham Colliery, Burnley.
1892	Ward, Alexander Haustonne, Ranigunj, Bengal, India.
1885	Ward, Thomas, J.P., F.G.S., Brookfield House, Northwich.
1880	Watts, William, F.G.S., 34, Wilkinson Street, Sheffield. *Past-President.*

Year of Election.	Names and Addresses.
1897	Wells, Lionel B., M.Inst.C.E., 5, John Dalton Street, Manchester.
1877	West, T. E., Union Street, Oldham.
1897	Whewell, John, Jun., Land and Mine Surveyor, Sharples, Bolton.
1890	*Whitaker, William*, B.A., F.R.S., F.G.S., Freda, Camden Road, Croydon.
1891	Whitehead, J. J., Bracklyn, Steven Street, Stretford, Manchester.
1898	Widdowson, J. H., 19, Brazenose Street, Manchester.
1867	*Wild, George*, Albert Street, Bardsley, Ashton-under-Lyne.
1880	Williams, Sir E. Leader, M.Inst.C.E., Manchester Ship Canal Company, King Street, Manchester.
1897	Winstanley, George H., F.G.S., 42, Deansgate, Manchester. *Member of Council.*
1876	Winstanley, Robert, C.E., 42, Deansgate, Manchester. *Past-President.*
1886	*Wood, Guy.
1897	Wood, John, M.E., Barley Brook Foundry, Wigan.
1897	Wood, Percy Lee, Newtown Collieries, Clifton, Manchester.
1898	Woodeson, W., 57, Roseneath Road, Urmston.
1876	Woodward, H. A., Oakwood, Clifton, near Manchester. *Member of Council. Hon. Auditor.*
1895	Wordsworth, T. H., New Moss Colliery, Audenshaw, near Manchester.

SUBSCRIBERS.

Stechert & Co., 2, Star Yard, Carey Street, London, W.C.

Eyre & Spottiswoode, 5, Middle New Street, London, E.C.

Members are requested to communicate to the Hon. Secretaries all changes of address, also any omissions, or corrections required in the list.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XXVI. SESSION 1898-99.

The ORDINARY MEETING of the Members was held on Tuesday, November 8th, 1898, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. CLEGG LIVESEY, J.P., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Members of the Society:—

Mr. GEORGE EAGLE, Winter's Buildings, 32, St. Ann Street, Manchester.

Mr. JAMES TONGE, Jr., 21, Mawdsley Street, Bolton.

Mr. J. BARNES, F.G.S., read the following paper on "The Superposition of Quartz Crystals on Calcite in the Igneous Rocks occurring in the Carboniferous Limestone of Derbyshire."

ON THE SUPERPOSITION OF QUARTZ CRYSTALS ON CALCITE IN THE IGNEOUS ROCKS OCCURRING IN THE CARBONIFEROUS LIMESTONE OF DERBYSHIRE.

By W. F. Holroyd, F.G.S., and J. Barnes, F.G.S., &c.

It is well known that there occur in all limestones, fossils, which are more or less silicified, *i.e.*, where the calcium carbonate has been partially or wholly removed, and its place taken by silica, which is sometimes crystalline, sometimes amorphous, and at others crypto-crystalline. We find this kind of replacement in the oldest limestones of the Cambrian System, and passing through every calcareous formation up to the most recent. It may be a shell, the hard parts of a coral, or stems of encrinites and parts of other animals which have thus been replaced. In the Mountain Limestone we find many examples of such replacements, specimens of which are laid before you on the table. Again, in the chalk, we find many of the fossils preserved in masses of flint, which is a crypto-crystalline form of silica; while at other times the silica assumes the form of quartz crystals.

This common interchange of silica with calcium carbonate is one of much interest, both to the chemist and to the geologist, *i.e.*, regarded from a chemico-geological point of view; for there are instances when silica does not take the place of carbonate of lime, or rather, has not been able to take the place of carbonate of lime, although present in solution after the calcium carbonate. We met with such an example during the past summer, while making an examina-

tion of the well known igneous rocks of the Carboniferous Limestone of Derbyshire.

In the Miller's Dale district the "toadstone" crops out frequently, and in some places is very vesicular, or amygdaloidal, many of the amygdules being of a considerable size, up to 38 millimetres in length by 16 in width. One of these specimens lies upon the table. The igneous rock is faulted and traversed by numerous veins running west and east, the veins being filled with calcite. In the rock are numerous pockets varying from 10 to 15 centimetres in length, 5 to 10 centimetres in width, partially filled, and surrounded with, angular fragments of the igneous rock itself, and cemented by calcite. Resting upon the latter are numerous well-formed crystals of calcite, the free ends of the scalenohedrons projecting from all sides into the cavity. Superposed upon these crystals of calcite are well-developed crystals of quartz, locally known as diamonds, the free ends of which form the usual six-sided pyramids, projecting into the centre of the cavity, almost filling it up. (*Fig 3.*) These crystals are semi-transparent, and have exceedingly bright smooth faces. Where the crystals touch the calcite, the faces are much duller, and are crossed by numerous fine lines. Where a crystal of quartz has not had sufficient room to develop fully, because of the closeness of the dog-tooth crystals of calcite, we find it has surrounded them; and now the quartz crystals frequently show numerous cavities, due to the subsequent removal of the calcite crystals. (*Fig. 1.*) In some cases the quartz crystals are almost loose in the cavity of the rock owing to this removal by acidulated water.

The question naturally arises, why does silica at one time replace calcite and not do so at another? From the occurrence of the quartz upon the calcite in these cavities, we see an instance in which silica has not had the power of replacing

the carbonate of lime. We know this because the quartz crystals are found superposed upon the calcite crystals, which must have been there previously. This goes to show that silicic acid is a weaker acid than carbonic acid, inasmuch as it has not dissolved the calcium carbonate. This is also shown by the opposite action, *i.e.*, that of carbonic acid in water having the power of decomposing such rocks as granite, &c. The silicic acid has only the power of taking the place of carbonic acid, when it has the assistance of some other solvent, such as carbonic acid itself, which is the one that dissolves away the calcium carbonate, and allows the silica which is in solution to take the place of the calcium carbonate. In the case of the toadstone of the Miller's Dale district the calcium carbonate appears to have been deposited first, lining the cavity; then a solution of silica free from carbonic acid or other solvent has occupied the cavity, and deposited the quartz crystals upon the calcite without dissolving them. (*Figs. 2 and 3.*) Whether the silica has come from below, or from the surrounding country rock we cannot say.

The silica has not in every case assumed the form of quartz crystals, for we also find it on the same horizon and in the same rock, assuming the form of banded agates, almost, or entirely, filling some of the smaller vesicles in the toadstone. They are of the usual amygdaloid form, and of a milky white and semi-transparent character, varied with lighter bands arranged concentrically.

The toadstone represents the upper or slaggy part of a lava stream. The little cavities have been opened by the segregation and expansion of the steam in the mass of lava. By the movement of the rock they have been drawn out and flattened into amygdaloidal vesicles, which have been subsequently filled up in three ways:—

Trans. Man. Geo. Soc. Part II. Vol. XXVI.
To illustrate Messrs. Holroyd & Harris' paper
"on the Superposition of Quartz on Calcite."

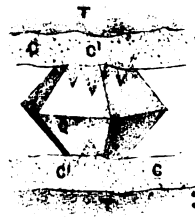

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FIG. 1.
Q Quartz Crystal upon Calcite Crystals C! C. Calcite. T. Toadstone.

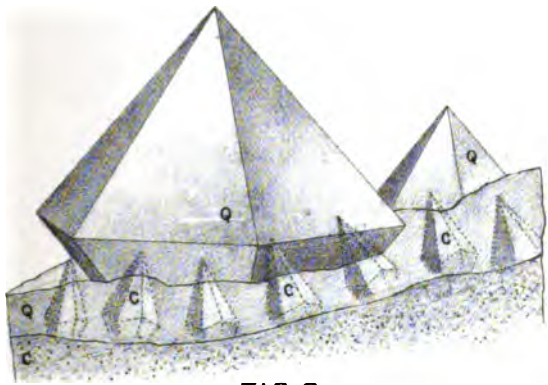

FIG. 2.
Shewing position of the Calcite Crystals C, in the Quartz Q.

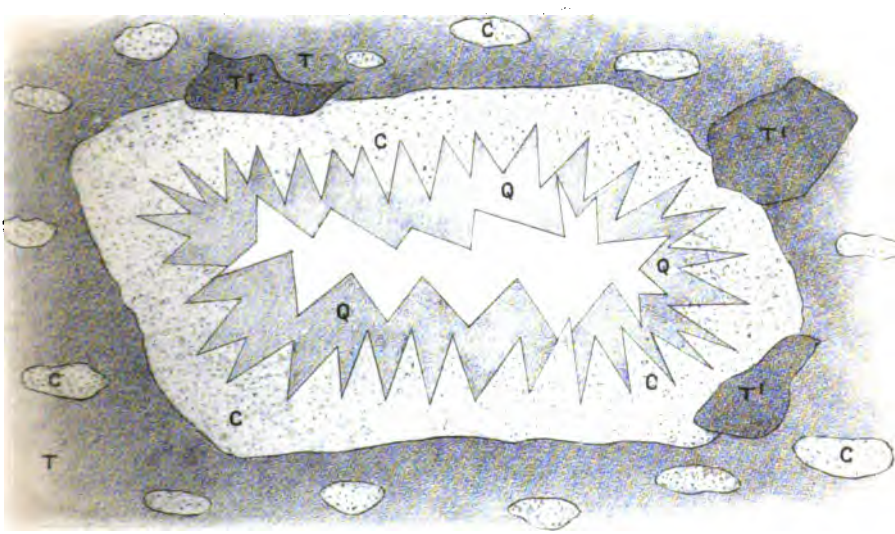

FIG. 3.
Section of a cavity in the Toadstone T, (with angular fragments of the igneous rock T') lined with Calcite C. upon which Quartz Crystals Q have been subsequently deposited.

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By calcite, forming amygdules.

By silica, forming chalcedonic banded masses.

By a layer of calcite crystals in form of scalenohedrons, and then a successive deposit of quartz crystals upon these.

These three kinds of infilling of vesicular cavities are shown upon the table; the first is common everywhere in the toadstone, the second and third are new to us as occurring in the Derbyshire igneous rocks, and hence our reason for recording them.

On the motion of Mr. SAINT, the thanks of the members were accorded to the authors of the paper.

The discussion on Mr. Joseph Dickinson's paper on "Subsidence caused by Colliery Workings," was resumed.

SUBSIDENCE CAUSED BY COLLIERY WORKINGS.

Resumed Discussion on Mr. Joseph Dickinson's Paper,

Read June 14th, 1898.

Mr. Dickinson, in opening the discussion, said: Members will have seen by the circular announcing this meeting, that in the diagram accompanying the paper, the artist has erroneously put figure 3 instead of 5 for the vertical depth to 1 horizontal, as the average slope in hard strata. The slopes for each kind of strata are correctly shown by the sketches, and the figures correctly given in the text of the paper; therefore, careful observers are not likely to have been misled by the error.

In the short discussion which took place immediately after the reading of the paper, June 14th, general agreement was expressed with the contents, and it was mentioned that among so many technical points all might not have been caught. One point which Mr. Edward Garside did not catch, was, the proportion of subsidence to be expected from the working of a given thickness of coal. The paper sets forth that subsidence of surface may be expected from the working of coal at all depths; and that it possibly decreases with increased depth of working. It also puts the subsidence from the working of a 4-foot seam, 200 yards deep, at about 3 feet; and gives a statement by Mr. William Peace, that, near Wigan, at 150 yards, a canal subsided 3½ feet from the working of a seam about 4½ feet thick; it also gives a statement by Mr. Alfred Hewlett, that, near Wigan, at 180 yards, from the working of a seam 7 or 8 feet thick, the subsidence was about 6 feet. To these Mr. Garside has

now added a subsidence at the Dunkirk Collieries, in Cheshire, where in 1878, at 445 yards, the taking out of two seams, respectively 6 feet and 5 feet in thickness, lying 50 yards apart, he found from bench marks, which he had put, that from the total of 11 feet worked out, the surface in five years went down 6·8 feet; and in the following five years 8·92 feet were gone. This ratio it may be said does not differ much from the average of about three-fourths stated in the paper. The continuance of the subsidence, however, after the first five years, scarcely harmonises with the statements quoted from Mr. John Knowles and Mr. William Alexander, that, with all worked out, the surface soon settles, and in about two years becomes safe for building upon. It would therefore be satisfactory to know whether the long continued subsidence at Dunkirk was after pillar and stall work, with some stumps of coal left, or could be due to other workings than those mentioned. Mention was made by Mr. Woodward of the discomfort occasioned to surface occupiers by having their houses pulled about, winds let in, water and gas mains broken, sewers and railways let down; and by Mr. H. H. Bolton, Junr., that even in the lower series of north Lancashire, annoyance was caused to the colliery owners by claims for compensation, when workings were, allegorically, "a mile away."

Since the paper was read and issued, communications sent to the writer, include the following:—

Mr. Thomas Bell, one of H.M. Inspectors of Mines, retired, and an honorary member of this Society, has this morning favoured me with 32 foolscap pages of manuscript, which I have not yet had time to peruse. I see they contain valuable information relating to workings under water, and that they will form one, if not two, fine papers, with which I hope he will favour this Society.

Mr. JOHN H. COOKE, Solicitor, Winsford, who has had very extensive legal and practical experience in the Cheshire salt districts, says he will associate what is said in the paper with my experience there. The landslips from rock salt mining, and the after inundation, solution, and pumping of the brine, however, differ somewhat from the ordinary subsidence caused by coal workings. Those caused by the pumping of brine, also from the runs known as "rock head brine," produce curious effects, resulting in immense holes and submergence. Some of these runs, without any exaggeration, extend fully two miles from where the brine is pumped.

Mr. ALEXANDER SMITH, M.Inst.C.E., Secretary to the South Staffordshire Institute of Mining Engineers, says he has read most of the literature on this important mining question, and that, although no rule can apply to every circumstance, yet the paper to his mind gives a good foundation and safe guide for nearly all practical purposes.

Mr. ROBERT THOMAS MOORE, B.Sc., 156, St. Vincent Street, Glasgow, says:—He has read the paper with care, and has to thank the writer for sending it to him. The subject is one in which he is much interested. In advising as to the protection of buildings, he has generally found that with the usual strata of Lanarkshire, where there is a good surface, a horizontal distance of one-third of the vertical depth is sufficient to protect the surface; but where there is any great thickness of surface drift, it is better to divide the allowance, and allow one-fourth of the depth for the strata, and take the slope through the surface drift at what it would stand on a railway embankment (*Fig. 1*). This latter allowance varies, from 1 vertical in 1½ horizontal, to 1 vertical in 5 horizontal, or even more, for soft muddy clay.

In addition to subsidence of the surface, however, which extends to some distance over the solid coal, he points out that there appears to be a lateral stretching of the surface, he having seen buildings cracked, where careful levelling could shew no difference before and after the seam of coal had been worked. He has tried to measure this by putting in pegs on the surface A. B. C. D. E., (*Fig. 2*), and measuring the distances between them carefully where the face was approaching them, but has never got any satisfactory results.

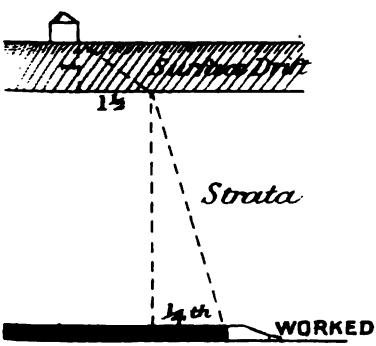


FIG. 1.

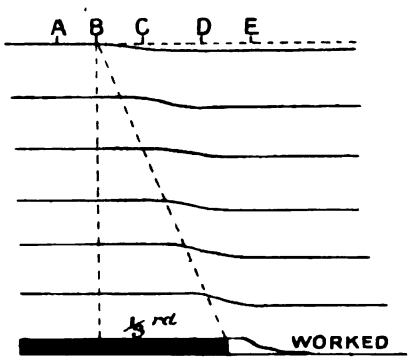


FIG. 2.

With regard to vertical subsidence, he has found, that with their strata, at depths of from 40 to 160 fathoms the subsidence on the surface is nearly three-fourths of the thickness worked. They have many opportunities of testing this. The Ordnance sheets were published in 1856—before any of the coal in the Hamilton district was worked—and a revised edition has just been published, so that the subsidence may be tested at each bench mark. He has some levelling going on just now at Niddrie Collieries, Portobello, where they are working a mine at a depth of 440 fathoms from the surface, and it will be interesting to see the total subsidence at this

depth. He also mentions the great value when persons who have had experience will take the trouble to give people the advantage of it.

With reference to these figures given by Mr. R. T. Moore for the Lanarkshire coalfield, at a horizontal of one-third of the depth, or, with an exceptional drift, at one-fourth of the depth for the strata, and a horizontal of 1½ to 5, or even more, to one in depth for the drift, they appear adequate for most, if not all, ordinary circumstances, including margins. His slopes for the drift are those of railway embankments. These, however, are devoid of the side support which is afforded in underground subsidence, and may, therefore, be often excessive for mining purposes. If they err, however, in being too flat, it is on the safe side for securing the building. The natural stretching of the ground by subsidence, which he has tried but failed to measure satisfactorily, is instructive. Yet, although it be scarcely measurable, there is stretching, and sometimes contracting, each being at times apparent in the tearing asunder of brickwork, masonry, and iron piping, and in the crushing of such like, and the lifting or turning aside of flags and coping stones.

Mr. Richard Sutcliffe, Mining Engineer, Horbury, Wakefield, has communicated the following to the Honorary Secretaries:—Being the person who started the longwall workings first under the 3-feet coal in the Jarrow seam Co. Kilkenny, I might say that it was commenced beneath an outlying or detached portion of the inundated upper seam, and, with the exception of drops of water from the roof (which occurred on the first subsidence of the strata, and continued throughout), no water came down. The total quantity which came would not be more than 40 or 50 gallons per minute. At first the miners were much

frightened, and insisted that the water was coming from the upper seam. I knew that even if it did come from the top coal, it could not come in sufficient quantity to cause injury, and so assured them. Since then the workings were extended under the main body of water contained in the old workings of the upper coal: The depth from surface is about 90 yards to Jarrow coal. There are from 10 to 12 yards of very compact rock, nearly midway between the two seams, containing several feet of flagstones. Although the water did not get down I have seen cracks on the surface, and even breaches where the surface fell into the old workings in the shallow coal, through the subsidence where the coal was taken out on the pillar and stall system in the Jarrow seam underneath.

It might be mentioned that the Jarrow seam runs in a channel 300 to 500 yards wide, and is only worked to this extent, beyond which it becomes thin, while the upper or 3-feet coal extended in all directions until it cropped out all around.

Mr. Dickinson added: I see by this that Mr. Sutcliffe was the first to introduced longwall workings into the lower seams of the County Kilkenny. He managed Mr. Robson's collieries at Clogh; they were at first worked pillar and stall, and afterwards changed to longwall. Now that the paper had been issued nearly a month, further criticism may be hoped for from members, with additional information, which will bring the subject up to date.

The Chairman invited discussion.

Mr. J. S. Burrows, of the Atherton Collieries, said: I think some of the variations in the practice of leaving certain arbitrary quantities of coal for the support of buildings arise from the fear of doing any damage whatever to the buildings intended to be preserved, and so ample margins

are left to cover all contingencies. Here the personal equation comes in; one man is more or less cautious than another and leaves a little more or less coal than his neighbour. Pillars left in coal mining are always a trouble, taking off the weight from the other places for some time, and causing other annoyances, even if left in the right place, which has not always been done. Pillars left in shallow mines for support of surface and buildings are for a long time liable to be upset again by the workings of the lower mines, and you never know how far movement may extend beyond the area immediately above such deeper workings. If it were possible always, there is no doubt sweeping out the whole mine in widework, if well packed, does the least damage. In a case in point, a mine nearly six feet thick, including holing dirt, was taken out in widework at a depth of from 190 to 260 yards. Two years afterwards another mine, five feet in gross thickness, 130 yards deeper, was taken out in a similar manner under numerous buildings, and caused no apparent damage. Bolting buildings enables thick seams to be taken out under buildings so protected, and with neat angle irons at the corners, and the bolts round the building neatly painted, such bolting is not unsightly. Having left coal for the support of buildings, one is not always able to trace the line of "draw" or "pull," so as to judge how much coal in excess has been left. In one case, I found in one mine four feet thick, 190 yards deep, dip of mine 1 in 5, the "break off" was clearly marked on the surface by a crack one or two inches wide. This was 45 yards south, or to the dip of the coal left for the support of the houses on the rise side. In another case, in the same mine, the line of "break off" was not at all clear, but an outhouse drew away from the larger building, which was undamaged. Here the depth was 165 yards, and the "draw" 33 yards south of the coal left for support.

In the same mine, at about the same depth, coal was worked on the south or dip side, up to within 20 yards of a large house, and to 40 yards on the north or rise side, without doing any appreciable damage; and again, 30 yards on the deep, and 40 yards on the rise, protected a similar large house. In the same mine at 100 yards in depth, coal was worked on the north or rise side, to within 23 yards of an old building, doing no damage. A little further away in the same mine 22 yards of coal left on the rise amply protected some cottages. In the same mine, at 45 yards deep, 23 yards of coal on the rise, with coal left east and west, and no coal worked on the south, prevented damage to a farmhouse which stood exactly over a 10 feet fault. The strata forming the roof of this mine are on the whole soft and the surface level, and in all these cases the buildings were the property of the Lessor. We found the working of this mine 160 yards deep lowered the surface at about $\frac{2}{3}$rds. of its thickness, and it was worked pillar and stall.

As a foundation for marking out coal to be left in mines dipping say 1 in 5, I let fall a line from the north or rise edge of the property to be protected, *at right angles to the seam*, then add to this a margin for safety; from the south or dip side a line is dropped at *right angles to the surface*, and again a margin added. These margins and the amount of coal left on the east and west sides depend on the nature and value of the property to be guarded.

Mr. Unsworth said: I only had the opportunity of reading Mr. Dickinson's paper as I came here in the train to-day, but I think that, having had a little experience of this matter, I may venture to give you some of the examples which have come under my notice, and which bear very distinctly upon this subject. It cannot be expected that I, after hearing what Mr. Dickinson has said, and after seeing the

authorities he quotes—gentlemen who spoke when his paper was read before the Society, many of them giants in the mining world—can have anything to add that will be very material or very important on this question. At the same time, there are one or two points that have come under my notice which are more or less corroborative of what Mr. Dickinson has said, and they also bear out what Mr. Burrows has said. Now, with regard to one of the last remarks Mr. Dickinson made use of to-day, wherein he spoke about mine subsidences having two effects, one of which was to sever or draw apart portions of a building, or an expanding effect; and the other a contracting or pushing together of the same building, or of other buildings in the immediate locality. I have had under my notice within the last few years an example of this kind, and this was the case of a church. The church stands east and west, and, by the getting of coal from underneath, it was broken off in a straight line north to south—completely broken off—one portion was severed and drawn away from the other. In connection with the same building, in a line running east and west, the operation of crushing together was distinctly manifested; a gateway which led from the churchyard into the road was contracted so that the two parts of the gate were brought nearer and overlapped in the middle, clearly showing in that case there had been a compressing effect. I have noticed it for a considerable time, but could never on any reasonable ground explain the divergent operations in the same building.

Now with regard to the depth at which mines are worked, and the quantity of coal that is necessary to be left for support of buildings, Mr. Burrows has pointed out, as also has Mr. Dickinson, that to a very great extent that must be left to circumstances. The circumstances of the particular place you have to deal with, and the nature of the strata you pass

through, all have to be taken into account; and further, the cautiousness or otherwise of the man who has to deal with the case, may have a very material effect whether he leaves much or little coal. An incautious man will shave it as finely as he can, whilst another who is careful, will leave more, especially if the mine pays badly, and he does not care for getting the coal, but wants to be sure he is not doing mischief. In my experience of working a mine which is about 5ft. thick (3ft. 6in. being coal, the rest dirt which comes in for packing purposes), 175 yards from the surface, I find that at that depth a block of coal 200 yards in diameter is not enough to secure the surface from absolute breakage. In the same mine I had a good opportunity of observing the amount of subsidence which took place. There is a reservoir which stands partly on solid, and partly over a worked area; the reservoir subsided, over that portion where the coal was gotten, from 2½ to 3ft., and this was proved by the increased height which it was necessary to make the bank, in order to prevent water in the reservoir from overflowing. This happened a good many years ago, and since the date of final settlement I have not noticed any further subsidence. The extent of the subsidence was distinctly marked, as that portion of the reservoir over solid coal did not subside at all. The coal referred to is a soft coal, and the overlying strata, with the exception of one bed of rock about 30 feet thick, is also of a friable character. Probably this fact explains why it is necessary to leave such a large area of mine to support the surface at a given point. From examples shewn by Mr. Dickinson in the diagrams given by him, and which I have no doubt will be accepted as authorities in future on all questions of this kind, he evidently considers that the strata passed through have a material effect in determining the area of coal to be left to support the surface at given depths. Large tracts of country are frequently affected by mining

subsidences, and this I have seen demonstrated by levels, taken for a railway in the district of Wigan some 35 years ago, which levels shewed, that at a certain point in that railway, where it crosses a canal, a subsidence of over 5 feet had taken place between the date of the ordnance survey in 1846, and the date of the new survey for the railway.

One point has been referred to with regard to water-bearing strata overlying coal workings; and where buildings have been erected on such strata, I have seen damage done by subsidence which happened before any coal was gotten, the water having been drained off by a main sewer. Any mining expert would have said it was a mining fracture if the whole circumstances had not been known to him.

These are a few of the points which Mr. Dickinson has put before us, and we, who have to deal practically with such matters, may, I think, derive very great advantage from studying closely Mr. Dickinson's paper, and using the information which he has given us.

I had a case not very long ago (a mining claim for damages), in which it was alleged the damage was done by me. The building damaged stood on a block of solid coal, extending 30 yards all round it, and the depth from the surface would be about 275 yards, the mine being from 2 ft. 3 in., to 2 ft. 4 in. in thickness. South of the solid coal there is a fault (upthrow to the south), about 21 feet, and further south an area of coal had been worked for about 130 yards above the fault. The whole of the workings near the building in question were done many years ago (and not by me), and while the workings were in progress, and for many years after, the building stood perfect. Some years ago, I began to work out the remainder of the coal, but did not work nearer than 130 yards (the

coal being already gotten to that distance, and the whole block of solid coal under the building remained intact). When a subsidence occurred, causing a distinct fracture of the building, it was alleged that my working was the cause. I am satisfied in my own mind that anything I have done could not by any possibility have moved that building, but again, an expert would, on an examination, have said that the damage was due to mining. The probable cause of the damage was, I consider, the draining of the strata near the surface by the local authority having constructed a deep sewer, which had, no doubt, drawn off water from a sand, which runs erratically through the district, and if this sand extends under the building, it may possibly have been drained, and so caused the subsidence and resulting damage.

Mr. MACALPINE said: I do not know of any paper which I have heard which has interested me so much as that of Mr. Dickinson, and some of the points which interested me most were those with which I had myself no practical acquaintance. I was astonished to find the shallow depths at which, under certain circumstances, mines may be safely worked under water. As far as my own experience goes I have had the misfortune to work a thin seam at considerable depth, but whilst that entails a great many costs in other ways, we have not very much to complain of in the matter of subsidence. The only words I can contribute to the discussion are these. It has been our practice in working under farmhouses, (which are the only kind of buildings we have had to deal with up to now), to sweep out the coal as we came across it; and this we have done both by pillar and stall and by wide work; but at a depth varying from 150 to 300 yards, we have not noticed any damage whatever by either method. There was one case, perhaps of some

little interest, which occurred two years ago. We had to work under a farmhouse, which we knew was very close upon a fault, and we were afraid the strata might break over that fault, and that we might have difficulty there, although we had not had any difficulty in the ordinary working. I therefore sent an architect over, and had the farmhouse carefully surveyed. We found the fault 20 yards beyond the farmhouse; we worked out underneath the house; but after two years the structure seems to be perfectly safe. The other point of interest—though of very secondary interest—is this. We have worked out under a winding of the Leeds and Liverpool canal. In some places, as this canal winds, the coal is there now; at other places it has been worked out, at a depth of 285 yards; and we have noticed no subsidence even on the banks. That would indicate, that, with a mine of about 2ft. 2in. to 2ft. 6in., having comparatively strong bands of strata over it, the subsidence is comparatively slight. I have no doubt when we have worked over the whole area, that there will be subsidence, but it seems to carry for 100 to 150 yards without any noticeable effect, as far as we can see. I may say that we have on that estate an opportunity of noticing this matter, of which we shall avail ourselves. There is a very tall chimney belonging to certain works now disused. We shall take out the whole of the coal under that area; I shall take observations of the top of the chimney as the work progresses, and if I find anything of interest to the members of this Society, I shall communicate it.

Mr. James Atherton said: I have had considerable experience with regard to this matter, but I am disposed to agree with Mr. Burrows that a great deal depends on circumstances. I do not suppose we can fix any definite rule that will apply to many cases of the same nature. My

own impression is that if you can sweep out the whole of the coal, and do it quickly, you are likely to do less injury than by leaving coal for support. In my own experience, at one time there were four buildings, or sets of buildings, requiring to be supported. In three cases they were farm houses and farm buildings, in the fourth it was a large mansion. Two of them were on one estate, and two on another. In each case surveyors representing the owners marked out an area of coal to be left for support, but afterwards the owner of one of the buildings began to relent. He thought that perhaps I was right, and if I got the whole of the coal it would perhaps be better; but before he would agree to this he had the royalty, in the pillars which it had been proposed to leave, valued. The valuation came to about £700, so he came to an agreement that we were to get out the coal in these two pillars and pay no royalty, but at the end we were to rebuild the premises at an expenditure of £700. In the other case the surveyor required the pillars to be left. When we had worked out both mines, in the case where we had the £700 to pay, the landlord came to us and asked us not to rebuild the place, because it was none the worse, but to hand him over the money, which we did. In the other case, where the pillars were left, the buildings are very much damaged. I attribute it, in one case, to the fact that we were working on one side, and we had to break off at a certain point, and this would pull the surface that way. When we came to the other side there was another break off. The pillars of coal were left, and the buildings were damaged:—now we are asked to drive through the old workings to clear out the pillars under the two places.

I know another case where the coal has been got out without leaving anything at all, and under a large area covered with buildings; but in that case there is a great

thickness of clay near the surface. I am not aware, in that case, that a single claim has been made for damage to buildings. The ground has subsided undoubtedly, probably 50 per cent. of the original thickness of the mine; but the clay has evidently formed a sort of cushion and prevented any fractures in the buildings. A great deal depends on the top ten yards. If you have ten yards of good clay I should say in my own experience clear out the coal and you need have no fear. On the other hand, if you have gravel, or sand and water, it is necessary to be very careful what you do, because it may do a good deal of damage, even a long way from where you are working.

Mr. Henry Hall said: Mr. Dickinson has dealt with the subject in a way which will be of great value to gentlemen who are fortunate enough to be called in, in cases of dispute; they will be able to refer to Mr. Dickinson's paper and see what they ought to do. Probably Mr. Dickinson, himself, will be called upon to stand by the principles he has set forth in his paper. There are two matters I should like Mr. Dickinson to tell us something about; one is whether or no the same principles he has laid down with reference to the subsidence of the surface would apply to the "pulling" of the shaft, or to the "pulling" of a mine road; the former particularly, because I have often found, that managers somehow manage to pull their own house about their ears. If the principles Mr. Dickinson has laid down apply to shafts, in the same way as to the surface, I think it would be very useful for many colliery managers to study those principles which have been laid down. There is one other matter I wish Mr. Dickinson would refer to in his reply. It struck me, in reading his paper, looking at it generally, that when you had a fracture going up to the surface its effect would depend to some

extent on the conformation of that surface. For instance, if the surface were hilly, the crack might extend up to, and cut off part of the side of the hill, when the hill itself might slide, and the damage extend a long distance further than is computed by the author of the paper.

The PRESIDENT said: My own experience commences from a very early date. When I was at home living with my father, (in fact, I was quite young), the coal had to be got under a house. It was a very large and very heavy building, and he was asked what must be done to it—how was the coal to be worked? He said: "Sweep it all out as quickly as possible. Do not hesitate—get it all out at once." And they did so; they proceeded to work right through; the house cracked down the middle, but as they worked on, in a very few weeks afterwards, the house closed again, and no more damage was done to it than you could have expected if it had not had any coal got under it at all. It was, in fact, a perfect success, and, I believe myself, it is much the safest plan to get all the coal out under a building, and to get it out as quickly as possible. I must say I am rather astonished at the amount of fall Mr. Dickinson names in his paper. I have not experienced anything of the sort myself; but it all depends on so many circumstances. If you have a flat mine you will have one result; if a steep mine you will have another. If you get it in pillar and stall work, you will have damage quite different from what you will have in longwork. There are so many different circumstances that I do not think the experience of any of us can serve as a guide to others. It is a most interesting subject, and we owe a debt of gratitude to Mr. Dickinson for bringing it forward.

Dr. BLACK said: It occurs to me that the dangerous character of gravel and sand arises from their being of a viscous

nature. If you tap a large body of water it will begin to flow out of the aperture, and the surface level of the water will subside. The same happens in a large body of sand; tap the sand on a lower level, and it begins to show on the surface of the deposit. The tapping of a bed of gravel at the lower part of the dip will occasion the impulse to be propagated through the whole bed of the gravel, up to its highest level, where it emerges on the surface soil; so where a house is built at the upper extremity of the dip it will be affected by mining. The effect of working 100 yards distant at the lower portion of the dip will be immediately transmitted from the lower to the higher level, without a great appearance of dislocation in the strata. The same effect would be apparent as if the whole of the strata of gravel had been composed of water, the particles of which are the counterpart of the grains of the other.

Mr. William Saint: The important question seems to be whether any system of working can be adopted to minimise the effect upon buildings. Which is the best way of approaching a building? Take the case of inclined seams; is it best to approach the buildings from the rise towards the dip, or from the dip towards the rise, or on the level? And, having worked out one seam under a building, what would be the best course with regard to the succeeding seam? Should the second seam be worked in the same direction as the first, or should the order be reversed or varied so as to minimise the dislocation?

Mr. Dickinson, in replying, said: The gentlemen who have spoken are practically conversant with the subject. The remarks with which Mr. Burrows has favoured us are from an engineer of very considerable experience, working a great number of seams; and the information he has given adds very much to the value of the paper. Mr. Unsworth

has also had very considerable experience in the working of mines of different thicknesses. He spoke of the two forces which I mentioned, with reference to Mr. Moore's observations, and he gave an instance where he had observed them both operating on or near to the same building. I have no doubt, that what he stated is strictly correct, and the explanation is easily found—that where you have an immense body of ground subsiding, there must not be only a drawing asunder, but also some squeezing together of certain parts of it. The instances I gave you of the lifting and pushing of coping stones aside and the cracking off of corners, clearly shows it. I have also known cases where the lifting of the rails on a tramway, has been attributed to the underground workings and the squeezing. Mr. Unsworth also mentioned the effect of sewers taking the water from beds of sand and gravel. There is no doubt that colliery owners are very often charged with causing subsidence where it is entirely due to the making of sewers and taking away water from sand and gravel. Sand makes a fair foundation as long as the water is not removed; when it is removed you get a very poor foundation, as was discovered when floods came in the earliest times.

Mr. Macalpine also has had considerable experience in the north Lancashire coalfield. He has a large colliery at Altham and Moorfields, and also at Great Harwood. He has not found any serious damage occasioned by the workings, and only in some very special cases has he found the surface subsided. He works a thin seam, from 26 to 28 inches; and I know that he packs it pretty well. A thin seam like that will supply plenty of dirt, and occasionally some may have to be taken out to the surface. But I know this also, that in his workings there is compression of the packing. That compression can only come from subsidence,

and although it is not observable on the surface, there must be subsidence, or the packings would not be compressed.

Then we had the views of Mr. James Atherton, a gentleman who has had very large experience of this subject. He is not only the managing agent of a large Tyldesley colliery, but he has also a very large general practice as a mining engineer, with many opportunities of observing. He has given you his experience, and it forms a valuable addition to this subject; I do not think any comment is needed upon it.

Mr. Henry Hall, one of Her Majesty's Inspectors of Mines, also has had many opportunities of observing, but he has confined his remarks on this subject more particularly to the drawing and moving of shafts and mining roads. There is not the slightest doubt that if a shaft or a road is in the line of the draw it must be twisted, and drawn out of place precisely the same as the surface. In fact, in South Staffordshire, where they work amongst very soft strata, the shafts used to be twisted so, that in going down in the skips without guides, you were in great danger of being thrown out through bumping against the curves in the shaft. The late Inspector for that district, Mr. J. P. Baker, recommended people to put a strap or chain round them before going down, in order to avoid being thrown out, and he, himself, used one. Many of the collieries were of very small area, so that they could not leave large pillars. In olden times it was a common practice to work the whole of the coal round about the bottom of the shaft, taking it clean out, and allowing the shaft to—as they called it—"sit down." And it sat down, often, but not always, straight. Those shafts were carefully bricked throughout. At one of the Ince collieries, Wigan, some 808 yards deep, to the Arley mine, I found the coal

about the shaft crushed into dust by the pressure. I mentioned to Mr. Bryham, the manager, what they did in South Staffordshire to meet such a case, and asked if there was any man bold enough in Lancashire to try it. The experience at present is that it is best to leave sufficient shaft pillars. They are tighter than you can put in any stowing, and they also help to prevent the surface subsiding, and perhaps damage to the winding and pumping machinery, screens, and such like. Another point Mr. Hall asked me to touch upon was the effect of subsidence varied by the conformation of the surface. There is no doubt it is varied. It is obvious it must be so. By one of the Lancashire and Yorkshire Railway Acts, where workings are approaching a canal, notice has to be given in working an inclined seam, when a right angle set up from the seam comes to the surface 100 yards from the canal, the surface measurement to be taken on a level with the water in the canal, so as to meet any varied conformation of the surface.

Dr. Black has mentioned the effect of removing water from sand and gravel. That is gone into pretty extensively in the paper. It only adds weight to what is said there.

I must also mention the President's contribution to the discussion. I have known Mr. Clegg Livesey 48 years, and I know that he has had a wide experience, not only in the work of his own collieries, but as a general practitioner throughout many parts of England, particularly in Lancashire and Cheshire, and I would only say the same with regard to what he has said, as I did in referring to the remarks of Mr. Atherton. His observations form a valuable addition to the subject.

Mr. Saint introduced new matter, as to whether it is safer to approach a building from the rise or from the dip, but

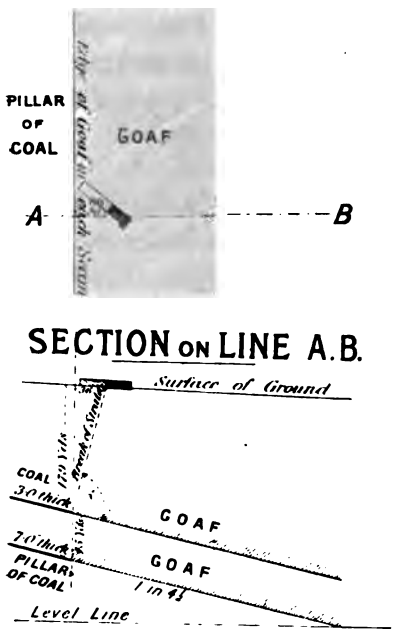
these are things that have really to be governed by circumstances. It is very rare that a person would work his coal down to the dip; the weight rides on the face, and makes the working dangerous. And then you have to take it in the way your workings naturally approach the building. Another question he asked was whether, having worked your seam near to, or underneath, a building, in working a lower seam it would not be better to vary the direction of the working. Supposing the first working had gone from East to West, whether the next one should not be taken from North to South? Again, as I said with regard to the way in which workings have to be laid out, you have to be guided by circumstances. You cannot always make a second working at right angles to the first. There is such a thing as a cleavage in the coal. If you do not work on the face you have generally to pay an extra price for working on the end, so it is impossible to lay down any general rule as applicable in all cases.

Professor W. Galloway, of Cardiff, it appears has read a paper on the subject. At the close of the meeting, a report of it from the *Colliery Guardian* of September 24th and October 1st, 1897, was handed to me by Mr. Mort. Summarising the report very briefly, it appears that: From early times continental mining engineers, like their contemporaries here, believed the disturbance of the surface to be limited by depth, more than has since been proved to be the case. A Commission, in 1827, reported that excavations not nearer than about 110 yards (100 metres) would not affect either houses or wells. This distance was doubted by a second Commission in 1839; and this doubting was not modified by a third Commission in 1859. Serious subsidence, however, resulting, the subject was reinvestigated by M. Dumont, whose report, extending over 331

quarto pages, is not detailed by the Professor. Further investigation was made by M. Fayol, to the effect that:—In horizontal mines, where the excavation is sufficiently large to affect the surface, the subsidence above the excavation increases gradually in extent up to a certain height, above which it begins to recede gradually until the extent becomes of similar area to that of the excavation. The height to which the subsidence increases is not stated specifically, but the greatest height shown is 760 feet. Commencing immediately above the excavation the depth of the subsidence gradually diminishes, until it ceases to be measurable, and the overlying ground is only slightly disturbed. In inclined mines the subsidence is mainly towards the dip. In some aspects M. Fayol's conclusions coincide with those in the present paper, but in other aspects there is divergence. The writer of the present paper has observed considerable disturbance of surface beyond the vertical line, where the depth of the excavation was 1,000 yards.—[J.D.]

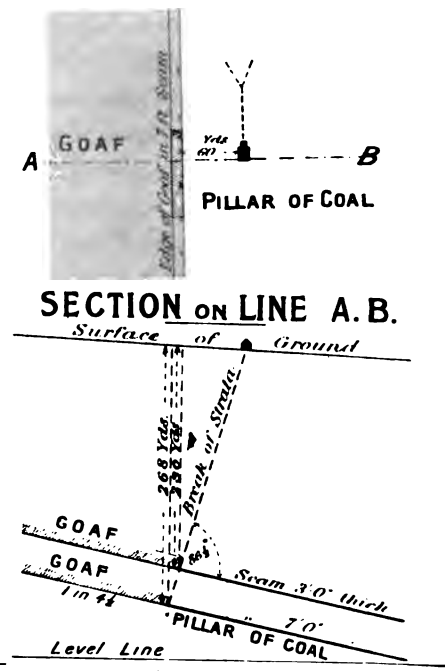
Mr. A. Dury Mitton, has since communicated the following: I have read Mr. Dickinson's very interesting paper about colliery subsidences and regret that I was not able to be present to hear the discussion upon the same at the meeting. There is no doubt that there is a great disinclination amongst mining engineers to express their views upon this important subject, owing to the great diversity of opinion that exists, and also owing to the fear of any special case used as an illustration being brought forward as evidence at any future date. I always think, however, that all mining engineers should keep a record of damages to property, as, comparing together the various occurrences tends to assist in forming opinions as to how to prevent damage to property, one of the lessee's most expensive outlays in colliery working. I give two sketches as worthy

of note. In Figs. 3 and 4 the whole of the coal was worked out underneath the buildings, from two seams of coal 3ft. and 7ft. thick respectively, at depths of 179 yards, and 224 yards respectively, and the workings being stopped at 36 yards to the rise of the buildings, the faces of the coal made a right angle break through the strata, pulling a row of



FIGS. 3 AND 4.

SCALE: 200 YARDS TO AN INCH.



FIGS. 5 AND 6.

SCALE: 200 YARDS TO AN INCH.

houses apart, so damaging the part of the houses shown in black that they had to be rebuilt and leaving the houses crossed unhurt. The plan and section, Figs. 5 and 6, shews an exactly opposite case of working the coal under a row of buildings, with similar results to those shewn before.

The coal here being left solid, and an almost identical break at right angles to the seam of coal.

Mr. H. Richardson Hewitt, one of H.M. Inspectors of of Mines, also has since sent his views. He recapitulates some of the leading points of the paper; and gives two instances of subsidence, one of them from the working of a four-foot seam at 230 yards, dipping two inches to the yard towards buildings, pulling them when the face was 88 yards away; and mentions that in North Staffordshire, over the very steep mines called "rearers," pillars have been left for the support of buildings not vertically under the buildings at all.

The latter mode of treating subsidence is mentioned in Part I. of the paper, and it apparently ignores the perpendicularity of gravity.—[J.D.]

THE LITERATURE CONCERNING SUBSIDENCE FROM COAL WORKING.

By Arthur Mort, B.Sc.

The object of this addendum to the recent discussion is rather to mention where further facts and opinions may be found recorded, than to attempt any adequate summary of the various papers named here; though some mention of their nature may be made. The papers referred to are:—

Mr. John Buddle (the celebrated viewer): Letter to Sir Charles Lyell, (quoted by H. W. Hughes, Jour. Brit. Soc., Min. Students, 1889).

Mr. J. Goodwin: Trans. Manch. Geol. Soc., Vol. IV., 1864.

Mr. W. J. Grimshaw: Trans. Manch. Geol. Soc., Vol. XIV., 1878.

Prof. Callon: Lectures on Mining, Paris. (translated by Foster and Galloway.) Vol. II., page 304.

Mr. J. S. Dixon: Trans. Min. Inst., Scotland. Vol. VII., 1886.

Messrs. Dron, Bulman, Longden & Gresley, in Jour. Brit. Soc., Mining Students. Vols. XI., XII., and XIII., 1889-90.

Mr. W. Spencer: Trans. Fed. Inst. Min. Eng. Vol. V., 1892.

Prof. W. Galloway: Trans. S. Wales, Inst. Eng. Vol. XX., Part 5, 1897.

Mr. S. R. Kay: Trans. Inst. Civil Engineers, London, November, 1898.

The papers of Messrs. Goodwin, Bulman, Spencer, and Galloway all induced weighty discussions and correspondence; together they record the views of most of our experienced men.

Mr. BUDDLE makes the interesting remark that, in his experience, subsidence is invariably greater with a sandstone than with a metal-stone roof.

Mr. GOODWIN, speaking of the breakage lines, puts his observations into the form of a table. I have tried to represent them graphically in fig. 7. They refer to seams 4 to 6 feet thick, at depths of about 200 yards, with different inclinations; and it is to be remembered that this is not a theory, but a record of facts by an evidently careful observer.

The diagram shows the amount of draw, and hence the angle of fracture, in working any of seven seams of different inclinations. Thus, it will be noticed, that for a seam (A) dipping 10°, the angle of fracture is 96½°, (greater than a right angle); for seam (C) at 20°, angle is 89½° (practically a normal); while for a seam (G) dipping 40°, the angle is

only 75½°, (less than a right angle). Evidently the direction of a line determining the position of fracture varies within much smaller limits than the range in dip of the seams. Also, the position of the surface break is shown as practically identical (b, c, d) for seams B, C, D, dipping 15°, 20°, and 24° respectively. Mr. Goodwin states also that the lateral draw in 18 different cases was 5° to 7°, *i.e.*, 1 horizontal in 8 to 11 vertical.

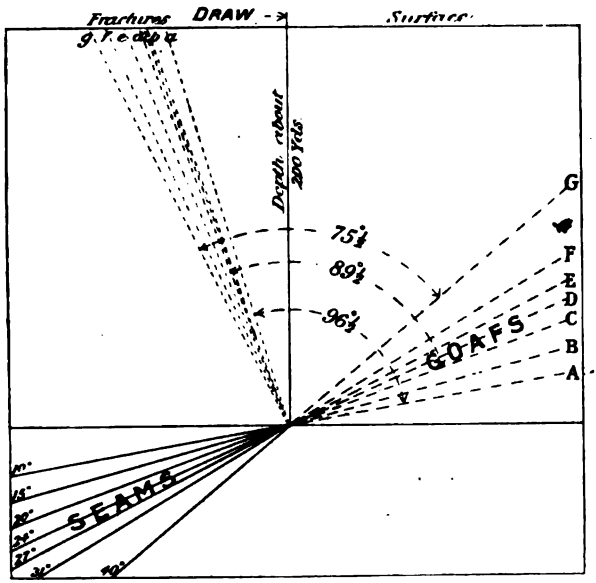


FIG. 7.

As bearing on Mr. Dickinson's suggestions concerning the probable angle of fracture through different beds, Mr. Goodwin is interesting. He considers that the breakage line of sandstone is more nearly vertical than that of shale, but from careful observations he concludes that the difference in the angle does not exceed 5°. The whole paper is a solid contribution, and has been oddly overlooked in more recent studies of the question. In the discussion Mr. Andrew

Knowles gave an amusing illustration of the fact that damage to buildings often tends to right itself as the workings proceed; a building was much damaged, and put right; afterwards, on working anew, it altered back again.

Mr. W. J. GRIMSHAW describes, with plan and sections, the effect on a reservoir embankment and neighbouring surface, as a seam 4 feet thick, dipping 1 in 3, at 66 yards deep, was worked from below. The maximum subsidence was 24 inches.

In the discussion Mr. Ratcliffe instanced a case of the longwall working of a seam 3 ft. 8 in. thick, under the river Clyde, where it was 200 to 250 feet wide, at a depth of only 52 yards. No water came through; a thickness of 17 yards of clay was known to exist below the river bottom.

M. CALLON, as the result of great experience in France, enunciated the "Theory of the Normal" viz.: that after removal of coal from an area, the subsidence of the roof on the pack causes fractures along the perimeter of the area at right angles to the measures. He also was of opinion that the subsidence within the area indicated by these fractures continues gradually, without sensible diminution in amount, quite up to the surface, whatever may be the depth of the mine. This "Normal" theory is widely held and acted upon by mining engineers in Lancashire.

Mr. J. S. DIXON records a series of levellings to determine subsidence and draw at Bent colliery, in Scotland; the paper has been largely quoted by Bulman, Brough, and others. A thickness of 5 ft. 6 in. was taken out, and the roof allowed to fall; depth 216 yards; dip 1 in 20. The subsidence was found to be greatest (4 ft.) towards the centre of the excavated space, and to diminish gradually in each direction.

The maximum "draw" (measured along level course of seam, to eliminate dip) was 1 ft. horizontal for each 6½ ft. vertical; and subsidence and draw had attained their limit in 18 months after ceasing work.

Mr. BULMAN's two papers are mainly an account of the work of the two great Continental authorities, Dumont and Fayol.

M. Dumont studied minutely the effect of coal working under the town of Liége. His results are complicated by the contortion, faulting, and inversion of the strata there. He believed in the theory of normal fractures. Mr. Bulman gives diagrams from him showing how the plane of fracture is affected by a change in the dip of the beds; by meeting with a fault; and by a surface "cover" of drift. As regards faults, the plane of fracture is shown as deflected into the fault-plane, which is, of course, itself a fracture. Thus a fault may reduce or extend the area of surface affected, according to its direction of slope.

M. Fayol's work is later. He took observations and levels for many years to see the results of workings of various depths, thicknesses, and inclinations in unfaulted districts; then checked his conclusions by experiments with models. As a result of this patient and thorough work, he, besides putting on record his facts, formulated what has become known as the "Dome Theory." This theory has the merit of largely correlating and harmonising the many otherwise irreconcilable results which have puzzled observers. Mr. Hughes remarks of M. Fayol's memoir:—"This paper is the most important one which has been published on the effect on the surface of coal working, and throws considerable light on what is perhaps the most intricate problem in mining, and about which few facts are known."

One of his many diagrams will serve to illustrate his chief points. (*Fig. 8.*) The part of the measures affected by withdrawal of support is represented as limited by a sort of dome (shown in section); the amount of movement diminishes by degrees as we get further, laterally or vertically, from the centre of the area excavated. The shape of the dome is dependent on thickness of excavation, area, depth, and nature of measures.

In the diagram, the effect does not reach to the surface S, and barely to S_1. If S were the surface, the area affected would be 2, 2, as if fixed by a vertical from A, and by a line almost normal to the seam from B. If S_3 were the

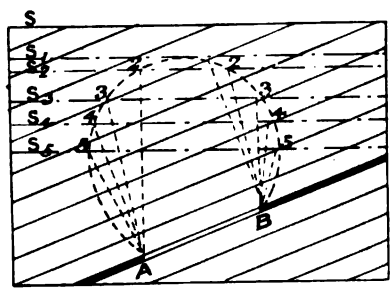


FIG. 8.

surface, the area affected would be 3, 3. If S_4, the area of subsidence would be 4, 4, which is seemingly limited by a normal from A, and by an almost vertical line from B. Lastly, if S_5 were the surface, the area affected, 5, 5, would indicate considerable "draw" on each side. M. Fayol found that the surface was convex (hence stretched and cracked) at the margin of areas affected; concave in the central portion. As the area extends the old cracks tend to close. He gives concrete examples of his conclusions. Thus he considers that a seam of one metre ($3\frac{1}{4}$ feet), worked out without packing, would, in measures largely sandstone, cease to affect the surface at 200 metres (say 220 yards) depth;

and with tight packing at 90 yards depth. Again, a seam 13 ft. thick, workings of any extent, waste unpacked, would not be likely to disturb the surface if over 900 yards deep. Our English experience is certainly not so comforting as this in many instances quoted by Mr. Dickinson and others. But the difference is probably one of degree and not of kind.

Mr. BULMAN, in his book on "Colliery Working and Management," applies M. Fayol's results to the determination of the pillars for a pit shaft working inclined seams. (*Fig. 9.*) The dotted curved lines shown in the diagram, between the verticals and the normals, indicate probable lines of fracture.

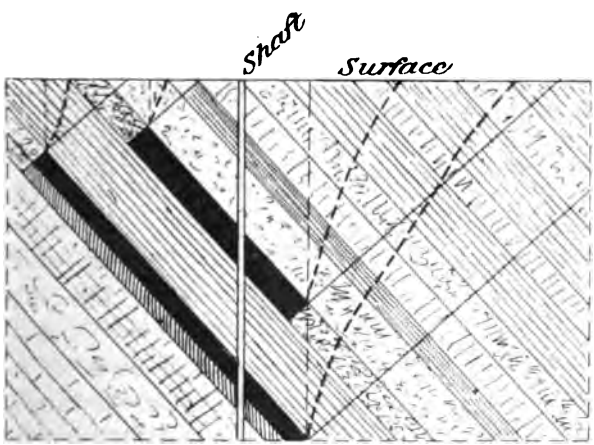


FIG. 9.

Mr. Bulman advises, as dimensions of the shaft pillars, "side of square $= \frac{1}{4}$ depth $+ 10$ yards." With deeper shaft, the pillars should, he holds, be larger even than this rule gives. The size most generally recognised as a safe and reasonable one is to make the radius of the pillar equal one-third the depth of the shaft; and some allow more on the rise side of inclined seams.

Mr. W. SPENCER, in his paper before the Federated Institution of Mining Engineers, gives plans and descriptions of some seventeen cases of working under or near buildings. He considers the results so diverse that he does not venture to generalise from them. None of them strikes one as very exceptional. It would seem that a building is least likely to be damaged if its length lie parallel to the working face of the coal.

Prof. W. GALLOWAY repeated before the South Wales Institution of Engineers what Mr. Bulman had already done for the Society of Mining Students, but more briefly in the case of M. Dumont's work.

Mr. Bulman's papers are now out of print.

The diagram (*Fig. 8*) here given to illustrate M. Fayol's views is taken from Prof. Galloway's paper.

Since the above discussion took place Mr. S. R. Kay has read a paper on "Subsidence" before the Institution of Civil Engineers. (November 29th, 1898.) He states that actual fractures of the ground are seldom caused by workings at depths beyond 100 yards. The effect on buildings is more in the nature of a "pull over" than of an actual break. Works should be placed away from goaf edges if possible, and two or three years at least should elapse, after removing the coal, before building. Bridges from beneath which coal seams will subsequently be worked should be built with strong well-bonded abutments and wings, with steel superstructure having an ample bearing on the beds. The form of the arch is to be avoided. The subsidence to be expected, amounting to about two-thirds of the thickness excavated, should, if necessary, be provided for in the first height of the bridge; otherwise provision should be made for the eventual raising of the superstructure to its

former level if required. Lofty viaducts should be protected by pillars; the piers should be solid, and should not be pierced by an arch.

Mr. Kay gives a formula which he considers satisfactory for determining the size of a pillar to be left, under normal conditions, for any depth and thickness of seam. Mr. Kay appears to hold that no greater area of pillar would be necessary with a seam dipping, say 30°, than if the seam were flat, but the pillar would simply need to be left towards the higher side. He has found, he further says, that the line of break in such cases is neither vertical nor at right angles to the dip, but midway between the two.

The whole of these papers and discussions reveal a strong and growing disinclination to leave pillars for support. This is especially true as regards buildings, where mere lowering is usually less serious than fracturing; to a less extent it is true of workings under canals, reservoirs, railway viaducts, and even water mains, which last are most sensitive of all to disturbances.

In this connection it is worth noting that the pillar which Mr. Dickinson suggests as necessary for the protection of a building, would be in case of a seam 400 yards deep, 4 feet thick, dipping 18°—(see his fourth diagram),—about 450 yards by 300 yards, representing over £4000 in royalty alone, at 6d. per ton.

REPORT OF THE DELEGATE TO THE BRITISH ASSOCIATION MEETING AT BRISTOL, 1898.

By Mr. Mark Stirrup, F.G.S.

As a member of the British Association it was my pleasure to attend the recent meeting at Bristol, and also to act as your representative at the meeting of the delegates of the Corresponding Societies which are affiliated to the Association, of which the Manchester Geological Society has the honour of being one. These annual meetings of the representatives of the Scientific and Natural History Societies, which are so plentifully scattered through the land, are thus kept in touch with that valuable perambulating organization—the British Association—whose object is the advancement of science in all parts of the kingdom.

In the last report of the Corresponding Societies Committee to the Council of the British Association, presented at Bristol, it is mentioned with satisfaction that the Corresponding Societies steadily increase in number, and that the total number of members composing them also increases. The Toronto report, 1897, shows 69 Corresponding Societies, having a total of 22,395 members.

The Committee publishes annually a list of the Corresponding Societies with an index of the papers read before each Society, giving the title and author's name, thus forming a record of local work, which is included in the annual report published by the Association.

Notwithstanding the fact that each Society has rightly its own scheme of usefulness and work to carry out, one of the benefits sought to be obtained by this union of local Societies to the British Association was the uniting, if need be, the members of these often widely separated Societies in a common

effort to a special end. For instance, may be mentioned those special investigations or enquiries which are set on foot by the Association, under the charge of various committees, yearly appointed, and which are in many cases, liberally aided by grants of money from the funds of the Association.

Two conferences of the delegates are called together by the committee, at each of which the delegates are expected to be present, and moreover, they are enjoined to report to their respective Societies the results of their deliberations.

To save time and avoid desultory conversation, often with no immediate aim in view, it has, of recent years, been thought better to fix the attention of the Conference on some special subject.

Thus, this year at Bristol, the subject for the consideration of the first Conference was the "Erosion of the Sea Coasts of England and Wales," and the delegates were invited to offer suggestions as to the best means of collecting information pertinent to the enquiry. Mr. W. Whitaker, F.R.S., President of the London Geological Society, took the chair, and opened the discussion. He pointed out that many of the most severe cases of coast erosion were due to the shifting of shingle and the wearing away of the beach by the action of the wind and the tide.

It may here be mentioned that a Committee of the British Association was appointed to investigate this matter so long ago as the year 1881, the Secretaries being the late Mr. W. Topley and our honorary member, Mr. De Rance. Numerous valuable reports have been handed in from time to time by members of that Committee and other gentlemen interested in the subject. Notwithstanding the information thus gathered the report presented to the Association in 1895 contains the following paragraph:—

"The late Mr. R. B. Grantham, M.Inst.C.E., F.G.S., in 1888, then Chairman of the Committee, stated—what is equally true in 1895 in the light of experience gained in the interval—that the papers hitherto prepared are very valuable, but they are unconnected, and do not give the means of enabling us to promote a system of protection in all parts of our coasts. It seems essential that the information, to be practically useful, should point out how a connected method of proceeding and operation could be formed to prevent the wearing away of land."

Such is the unsatisfactory pronouncement of the Committee after 14 or 15 years of inquiry, and I fear that the question was not much advanced by the suggestions and recommendations offered by the delegates at the Conference, the result of which is embodied in the following resolution which was passed:—"That the Council of the British Association be requested to bring under the notice of the Admiralty the importance of securing systematic observation on the erosion of the sea coast of the United Kingdom, and that the co-operation of the Coastguard might be profitably secured for this purpose."

Engineering skill has apparently so far failed in providing an efficient means of protection to those parts of our coast liable to waste from inroads of the sea, notwithstanding large sums of money spent by private owners of land and corporate bodies. Examples of the great loss of land sustained by some of the maritime counties are notorious in some parts of Kent, Sussex, and Hampshire, and are visible near at hand on the Lancashire coast at Blackpool and the Holderness coast of Yorkshire. If it be thought necessary that concerted and comprehensive measures should be undertaken to preserve our wasting shores, it seems useless to hope for, or expect, united action on the part of the owners of the coast lands, who are naturally only concerned with

the protection of their own property, therefore it would devolve upon the government as a work of imperial interest. The difficulties surrounding such a project seem insuperable and would reasonably deter any government from meddling with it. Some legislative limitation to the rights of owners of coast lands seems however necessary, where the taking of shingle, sand, &c., endangers the stability of the coast line, and especially in the destruction of sea cliffs for lime and building stone, when the rocks or cliffs act as a barrier to inroads of the sea, and as a protection to neighbouring land.

The second Conference of the Delegates was occupied in considering reports from the various sections of the Association. These reports point out where the help of local societies may be advantageous in carrying out researches proposed by the respective sections. Prof. Sylvanus Thompson began with some remarks and suggestions on the desirability of uniformity in the size of the pages of the printed matter and reports issued by scientific societies, a recommendation which, after considerable discussion, was favourably received, and a general opinion expressed in favour of uniformity wherever possible.

Dr. Garston then drew attention to the work of the Ethnographical Survey of the United Kingdom, and offered suggestions as to the way in which local societies might assist. The object of the Ethnographical Survey Committee—which was established some four or five years ago—"is to obtain a collection of authentic information relative to the population of the British Isles, with a view to determine as far as possible, the racial elements of which it is composed." To this end, the collection of folk-lore—current traditions and beliefs—observations or peculiarities of dialect, descriptions of existing ancient monuments, as cromlechs, barrows, &c., are desired. Inquiries such as these are altogether

outside the work of our Society, yet there may be some of the members interested in local history and antiquities who might be willing to help this Committee. If such is the case, an examination of the copy of the Schedule of Enquiries, with explanatory notes attached—(now laid on the table)—will give a better idea of the method and scope of work recommended to be followed, than this brief notice.

The foregoing *resumé* contains a compendium of what took place at the two conferences of the delegates, and at this point my report might well close, but following the custom of previous years, I would, with your permission, ask your attention to a few brief remarks on some of the papers brought before the Geological Section of the Association, which struck me as having some interest for us.

The address of Mr. Hudleston, F.R.S., the President of the Section first claims attention, but as it is naturally, mainly concerned with questions relating to the geology of Bristol and of that of the West of England, I need only indicate its purport, without giving any lengthy abstract. There is one question, however, with which Mr. Hudleston deals, of which I ought not to omit mention, knowing the interest taken in it by some of our members, and that is, the probability of the extension of the Dover coalfield to the west of England. Mr. Hudleston deprecates the continuance of those costly borings in East Anglia as a field both unpromising and unsuitable. He says, "if coal is to be found beneath the Secondary rocks, the line of search should be carried through the counties of Kent, Surrey, Berkshire and Wiltshire, though the three latter counties have hitherto been content to leave their underground riches unexplored. The Kent Coal Exploration Company is doing some good work with a reasonable chance of success; though if they wish to find coal sufficiently near the surface they had better adhere as much as possible to the line of the North Downs, since

operations on the Sussex side are only too likely to be within the influence of the Kimmeridgian Gulf which was proved to exist at Battle."

On a subsequent day the veteran, Mr. Etheridge, F.R.S., gave his views "on the relation and extension of the Franco-Belgian Coalfield to that of Kent and Somerset." Mr. Etheridge described a visit he had recently paid to the Mons coalfield, where he got samples of the coal which he found to agree well with that of Dover, both being of the same bituminous character. Furthermore, it was stated that the Mendip coal was an exact counterpart of the Belgian. He spoke hopefully of the future of this new English coalfield, and remarked that "some people said there was no coal at Dover, but he could tell them there were eight very good seams and he had no doubt they would soon be worked. There could be little doubt of the value of the South East Kent Coalfield, and he could speak of its continuity with the continental coalfield, having been along the great range from Liége right through."

Turning now to another subject which has more than local interest, I would refer for a few moments to a paper given by Mr. E. B. Wethered, F.G.S., on the "Building of the Clifton rocks," in which he shows that the cliffs of Carboniferous Limestone, forming the grand gorge of the Avon at Clifton, were due in large measure to microscopic calcareous organisms, whose structure was exhibited in some beautifully prepared sections thrown on to the screen by the aid of the lantern. Crinoids, corals, polyzoa, ostracoda, foraminifera were all represented, with some very minute and curious encrusting organisms which apparently lived at the bottom of the ancient seas, but whether these were of animal or vegetable growth is a question still undecided. Mr. Wethered's careful microscopical examination of the various beds of limestone composing the Clifton rocks has enabled

him to offer evidence in support of a correct stratigraphical arrangement of rocks whose position in the series might have been open to doubt, owing to the great folding and faulting they have undergone. He finds that certain beds contain dominant forms of life to the exclusion of others; for instance a stratum where encrinital remains prevailed, another stratum largely made up of bryozoa, another where the ostracoda were in the ascendant, and so on, showing that the presence of certain forms of animal life were regulated by the physical conditions under which they lived, the same as in our present ocean depths.

The Committee on "Life-Zones in the British Carboniferous Rocks" presented a short report, mainly dealing with the deposit of Millstone Grit Age, recently explored at Eccup, near Halifax, from which an extensive collection of fossils was made. The report notifies that the specimens have been distributed among the palæontologists specially appointed by the Committee, from whom full reports have not yet come to hand. The collection is said to be rich both in species and individuals, and probably the most valuable one that has been made from the Millstone Grit. The collection is to be deposited in the Museum of the Geological Survey, in Jermyn Street. These facts will probably be of interest to those of our members who saw the large and interesting collection of marine mollusca recently exhibited in these rooms, from the Millstone Grit at Pule Hill, near Marsden, by our members Messrs. Barnes and Holroyd.

The Committee on "Photographs of Geological Interest in the United Kingdom," presented their ninth report, giving a list of the last year's additions. The collection is stored at the Museum in Jermyn Street, and may be seen by application to the librarian. The loan collection of prints and lantern slides, useful for the illustration of papers, is now available for the use of societies.

An important paper entitled: "On the Revision of South Wales and Monmouthshire by the Geological Survey," was submitted to the Section by Mr. A. Strahan, one of the Surveyors. The paper deals mainly with the stratigraphy and structure of the coalfield, and the progress of the mapping. The original geological survey of South Wales under Sir Henry de la Beche (1840 or thereabouts), and that of Sir W. E. Logan (1831), have become practically almost useless, owing to the great extension and development of the coalfield in recent years. During the present decade, a revision of the survey has been going on, with varying progress, according to the increase or decrease of the staff of surveyors, but Mr. Strahan is able to announce that at the end of 1897, 1,000 square miles had been surveyed, in which 5,011 miles of geological lines had been traced upon the maps. As this paper may not readily be accessible to the members, I perhaps may be permitted to abstract two or three paragraphs for their information.

Re Maps.—"The work is engraved on the 1-inch New Series Ordnance Maps only, but the lines are all traced in the field on the 6-inch maps. Clean copies of these working maps are deposited in the office, and can be consulted or copied as soon as the corresponding 1-inch sheet is published. At the same time sheets of vertical sections illustrating the Coal Measures are prepared; two of them, giving series of shaft-sections in Monmouthshire and Eastern Glamorganshire, have been published, and others are in preparation. Explanations to accompany each sheet of the map are also being written; in these the local geology will be briefly explained; but it is proposed to describe the Coalfield as a whole in a separate volume when the revision is complete."

Re the Geology.—"In order that the map of the Coalfield should present the structure as conspicuously as possible, it was necessary to sub-divide the great mass of Coal Measures

which had been represented by one tint only on the old map. At the eastern end of the field it was apparent that a suitable three-fold division of the strata held good, the three divisions not only differing in their mineral contents, but presenting such physical features as lent themselves to the purposes of the geological surveyor. I wish, however," says Mr. Strahan, "to point out that no correlation is intended with the Upper, Middle, and Lower Coal Measures of other fields. Not only is it extremely improbable that any representatives of the Upper Coal Measures exist, but it is an open question how much of the Middle Coal Measures are present in South Wales."

The subdivisions referred to consist of:—

1. An upper series of shales and felspathic sandstones, with a few thin seams of coal and ironstone. The sandstones are often indistinguishable from Pennant, but the series is softer on the whole, and forms cultivated land of flowing contour. For its base, the Mynyddislwyn seam, a valuable and constant house-coal, served conveniently.

2. The Pennant Series, which in Monmouthshire is made up almost wholly of hard current-bedded highly felspathic grit with a few thin and impersistent coal seams. This series forms uncultivated moorlands, intercepted by deep valleys with rugged sides. At its base occurs the seam variously known as the Red Ash, Tillery, Brithdir, or No. 2 Rhondda.

3. The Lower Coal Series (Steam Coal Series of Glamorganshire), which consist principally of shales and thin beds of quartz-grit. This series contains the thickest seams of coal, and the bands or nodules of clay-ironstone which were formerly worked in South Wales. It crops out all along the margin of the coalfield, but is exposed only in the deepest valleys, or along the crests of the anticlines in the more central parts.

I must refer you to the paper itself for further details on the Coal Measures, and for remarks on the great flexures and faults which disturbed the district in pre-Triassic times, as well as for information on the other rock groups. A point of interest to glacialists may be noted, due to the mapping of the glacial deposits at the same time as the solid geology, when this important fact was brought out, that South Wales formed a small *independent* centre of glaciation, and as Mr. Strahan says exhibits phenomena of great interest. He goes on to say that "the southern limit to which the ice reached is no less clearly marked than its birthplace, for the gravels get finer and thinner, and eventually die away, sometimes before reaching the shores of the Bristol Channel."

The last paper to which I purpose to draw your attention is one by Professor Hull, one of our Honorary Members, "On the Sub-oceanic Physical Features of the North Atlantic," indicating subsidences of the ocean floor on the Atlantic Sea-board of the British Islands, and southward off the coasts of France and Spain. These interesting submarine depressions, or "deeps," as known to mariners are indicated by the soundings marked on the Admiralty Charts. Their nature is explained as being ancient river channels, some of which are remarkable for their limited width and precipitous banks, similar in formation to the well-known cañons of Colorado. These physical features are recognised as due to sub-aërial causes, and of only recent geological age, so that the British Islands must have been submerged, probably in preglacial times, 1,000 to 1,500 feet.

An American writer on similar phenomena on the North American coast, says that the "vertical amount of preglacial elevation of North America during late Tertiary and early Quaternary is shown to have ranged from 3,000 to 5,000 feet, according to the soundings of fiords and submerged valleys on our Atlantic, Pacific and Arctic Coasts."

The great interest which attaches to these explorations is that they seem to afford an explanation of the problem, the "Cause of the Ice Age," without having reference to those cosmic or astronomical causes which have from time to time been promulgated. Professor Hull points out "how such an uprising of the lands, as described, must have affected the climatal conditions, resulting in a general lowering of the temperature; and, in connection with the alteration in the course and temperature of the Gulf Stream, must have brought conditions over the northern hemisphere such as those which are inferred to have been in force during the Pleistocene or Glacial period.

In submitting the above summary of papers of geological interest brought before Section C. at Bristol, I may have missed much that would have been interesting to report to the members, but I have selected such as I thought might be the most acceptable and appropriate, without wearying you with a long communication.

On the motion of Mr. SAINT a vote of thanks was passed to Mr. Stirrup for his Report.

Mr. DICKINSON said: Mr. Stirrup had omitted to mention an important paper by Mr. T. Forster Brown, a Mining Engineer of world-wide experience, and principal mining agent for the Crown Mines. His paper gives a most interesting account of the different machines employed in the getting of coal, and mentions how the shallow mines are being worked off. He expresses his belief that in fifty years from this time the country will begin to feel that its best mines are being exhausted, and increased cost of coal may be expected.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART III. VOL. XXVI. SESSION 1898-99.

The ORDINARY MEETING of the Members was held on Tuesday, December 13th, 1898, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street.

Mr. JOSEPH DICKINSON, F.G.S. (in the absence of the President), in the Chair.

NEW MEMBER.

Mr. LEVI J. HALL, of the Collieries, Furness Vale, near Stockport, was balloted for and duly elected a Member of the Society.

BRITISH ASSOCIATION LOAN COLLECTION OF GEOLOGICAL PHOTOGRAPHS.

Mr. C. R. Lindsey brought before the members the Loan Collection, of the British Association Committee on Geological Photographs. About nine years ago, he explained, a Committee of the British Association was appointed to undertake the collection, preservation, and systematic registration of photographs of geological interest in the United Kingdom. Since its formation, the committee had accumulated about 2,000 photographs, which were deposited for public inspection at the Jermyn Street Museum, London; and besides these they had about 200 duplicates which were lent on loan to societies such as theirs. That loan collection was now before them for inspection, and it would remain in the rooms during the rest of the week. On Friday night, at a special meeting, about a hundred of the principal photographs would be exhibited by the aid of the lime-light. He moved that the thanks of the Society be given to the British Association Committee for the loan of their interesting photographs, and to Prof. W. W. Watts, the Secretary, for his trouble in the matter. The motion was seconded by Mr. Stirrup, and passed unanimously.

COAL FOSSILS FROM AGECROFT.

Mr. MARK STIRRUP, F.G.S., called attention to some specimens which he exhibited of Carboniferous fossils from the Agecroft sinking, and from the roof of the Rams Mine, which he got during a visit to the locality in October. These were chiefly specimens of species of Calamites which exhibited the sheath and the teeth of the sheath, which are characteristic of the jointed stems of the Equisetaceæ of the present day. On one specimen there was also an example of *Spirorbis carbonarius*. These fossils lay on the waste heap at the time he was there, having recently been brought to bank.

Dr. WHEELTON HIND, F.G.S., delivered the following address on "The Correlation of the British and European Carboniferous Beds."

AN ADDRESS ON THE CORRELATION OF THE BRITISH AND EUROPEAN CARBONIFEROUS BEDS.

By Wheelton Hind, M.D., F.G.S., &c.

Illustrated by specimens from the Cabinets of Messrs. W. F. Holroyd, F.G.S., and J. Barnes, F.G.S., &c.

During the last two or three years I have published several papers on the subject of the correlation of these rocks in Great Britain, and one similar paper on their correlation with those on the Continent. I propose now to give to you the conclusions at which I have arrived, which conclusions are not those generally accepted in the text books, but are those to which the officers of the Geological Survey are, by a gradual process, coming.

The great difficulty in the correlation of British Carboniferous rocks is due to the fact that although in one district they may exhibit a certain sequence, in another the sequence is an entirely different one. I am only going to discuss the question of the correlation of the beds which come below the Millstone Grit; and I would ask you to let me, first, describe the sequence of what I may call a typical section of the Midland district—take Derbyshire or North Staffordshire. There lies at the bottom of the Carboniferous beds a great mass of Mountain Limestone which has never yet been bottomed. There are some 2,000 ft. or 3,000 ft.—all limestone. I do not think so much has ever been measured, or exposed, because I think the re-survey will demonstrate the fact that there are a number of foldings in Derbyshire, and that we

never get quite as much as that; but suffice it to say there is a thick mass of undivided limestone which forms the base of the Carboniferous Series of Derbyshire. Above the limestone there are two or three thousand feet of black shales. The curious thing is that the fossils and lithology of those black shales are so essentially different from those of the Mountain Limestone. They form different series. They have been mapped as the Yoredale series, but I think that is a mistake, as you will agree with me when we examine the palæontological character of the beds which are found in Yoredale, and which are to be taken as the type.

I want you to remember that between the Millstone Grits of the Midlands, including Derbyshire, and the main mass of the Mountain Limestone there is a very thick mass of black shales, with thin curious seams of limestone, a sample of which I have here. You will all recognise that there is nothing in character common to this limestone and the Mountain Limestone of Derbyshire. These beds of limestone are sometimes 30ft. or 40ft. in thickness, and may consist of two beds or series separated by 200 ft. of shales, and these come 200 ft. or 300 ft. above the Mountain Limestone of Derbyshire. They can be traced through North Staffordshire, Derbyshire, and Yorkshire as far as Pendle Hill, where they form what is locally called the Pendle-side Limestone by the Geological Survey. This latter is an exceedingly pure limestone, and fossils are rare in it. Those found are characteristic of the shales, and resemble those that Messrs. Barnes and Holroyd have brought before this Society from a similar horizon at Pule Hill, near Marsden. The Goniatites have generally their cavities filled with some petroleum or mineral oil. This rock is exceedingly characteristic of that horizon, and will be useful as a datum line for the re-survey of the district. It is somewhat thicker at Pendle than it is in Staffordshire.

Passing northwards to the typical sections in the dales of Yorkshire we come to Ingleborough; and at Ingleborough we have a very curious sequence. The Thornton Force section shows at the base a bed of conglomerate, with quartz pebbles and a few Carboniferous Corals (with some Carboniferous Limestone pebbles too), resting on the up-turned edges of the Silurian rocks. Above this is the Great Scar Limestone, which is about 600ft. thick. Then, ascending Ingleborough, the following series of rocks is seen:—First, a series of shales and sandstones; then a bed of limestone, 30ft. to 40ft. thick, the Hardraw Scar Limestone; above this another series of shales and sandstones, and then another bed of limestone called the Simonside Limestone. After that again another series of shales and sandstones; then what is known as the Middle Limestone, and another series of shales and sandstones; and above all these comes the Main Limestone. These limestones all stand out as white bands on the scarp of Ingleborough. Then there are 120 feet of shales, and Millstone Grit at the summit. This is called the 40 fathom grit.

We have here a totally different sequence from what we have in Derbyshire. Instead of having a great mass of limestone at the bottom, we have only 600 feet left; this can be measured perfectly. There is a conglomerate at the bottom, resting on the up-turned Silurians, so that we have there the whole sequence of the mass of beds that is left. All those other beds, in which occur four definite limestones on Ingleborough, containing characteristic Carboniferous Mountain Limestone fossils, separated by beds of sandstone and shales, occur 20 miles further North in Wensleydale or Yoredale. But here there is not quite such a simple condition as at Ingleborough, for there are some new limestones intercalated, the Underset Limestone and other thin beds, coming in there.

The whole of this series at the top of Ingleborough is about 900ft.; the part below is 600ft.; making 1500ft. of beds altogether, which represent the whole Carboniferous Series beneath the Millstone Grit.

But in Derbyshire there are two or three thousand feet of what are called Yoredale Shales, with the peculiar limestone mentioned above, and another two or three thousand feet of Mountain Limestone. The great point is the remarkable way in which the Great Scar Limestone, which is supposed to represent—though I do not believe it for a moment—the mass of the limestone in Derbyshire, has dwindled to 600ft

Now, if instead of going to Ingleborough we went up Wharfedale and examined the flanks of Great Whernside we should find there is nothing between the Simonside Limestone and the Great Scar Limestone. The Hardraw Scar Limestone is absent; farther south other beds are absent, and the Main Limestone is very thin. Therefore if we take a more easterly direction and go along Wharfedale we find, that, as Phillips laid down long ago, as the Mountain Limestone passes north it splits up, the upper beds being separated from the lower by bands of shales and sandstones which thicken as they pass north. That is to say the upper part of the Carboniferous Limestone becomes separated by intercalations of sandstones and shales. It is to this series of separated beds of limestone which occur in Wensleydale (or Yoredale) that the name of the *Yoredale Series* has been applied. Well, if that be the fact, if the Yoredale series be nothing but a splitting up of the Carboniferous Limestone of Derbyshire, the Yoredales are not *above* the limestones in Derbyshire, and the black shales we have there are a totally different series to the typical Yoredale series, and do not belong to this series at all, and really belong to a much higher horizon.

This is one of the points I am anxious to prove, namely, that the series mapped in Derbyshire as the "Yoredales" have nothing whatever to do with the Yoredale rocks of Wensleydale.

The Yoredale rocks of Wensleydale are a series of limestones and shales, and if anyone familiar with the Derbyshire limestone went into a quarry anywhere in that district he would at once say "this is the limestone of Derbyshire."

These beds, still going north, split up, and the Great Scar Limestone at the bottom becomes thinner and thinner. At Melmerby Scar, east of Penrith, and west of Alston Moor, there is a totally different series from that which obtains in Wensleydale. At the bottom is a bed of conglomerate, which instead of being 6ft. or 8ft. thick, as at Thornton Force, is now 200ft. thick. It is a conglomerate with beds of sandstones and shales, and a few thin limestones; then comes the Melmerby Limestone, which is only 200ft., broken up into various beds; then beds of sandstones and shales, and a series of limestones coming on for another 200ft.; so the 600ft. of the Great Scar Limestone is broken up into 400ft of limestones and shale, the main mass of limestone at the bottom being left as only 200ft. Thus, where we started with 2,000ft. or 3,000ft. in Derbyshire and South Yorkshire—at Clitheroe the main mass is not divided—in Wharfedale, we have it 900ft.; at Ingleborough, 600ft.; in Wensleydale, 500ft.; and at Melmerby, it is only 200ft.; and we have at the top of this the Alston Moor series of limestones, which are the same limestones which we have elsewhere, only they have a different series of names, and there are a few more of them, because they become thinner and split up into beds.

This series is very easily observed because the country in north-west Yorkshire has hardly been faulted at all. The

country is a table-land, with a series of deep parallel valleys, and both sides of these valleys are alike; the scarps of the limestones have been worked back, and the streams, where there are streams, fall over these scarps, giving to Wensleydale its title of "the dale of a hundred waterfalls." Where these limestones have different names, they can be traced from one dale to another. Wensleydale is divided from Swaledale by a very steep hill or divide, the valleys are parallel, and the same rocks appear in the neighbouring valleys.

This condition of things goes on from Wensleydale to the south of Northumberland; there are few valleys, and, standing on one hill, all the other hills are seen to be about the same level, and all are capped with Millstone Grit. The lines of the other limestones can be traced as features which form a series of steps all the way down.

Further north still, in Northumberland, there is no mass of limestone which can be called the Great Scar Limestone, or which can be called the representative of the Carboniferous Limestone of Derbyshire, because it is all split up into various beds. There is no limestone thicker than 30 ft. or 40 ft. The whole of these limestones—and there are from 16 to 20 of them—are named, and they are all worked and quarried in different localities in the north of Northumberland. They are separated by various thicknesses of sandstones and shales. There is therefore nothing in Northumberland similar to the Carboniferous sequence as known in Derbyshire. And, curiously enough, in these shales are beds of coal, the chief coal-bearing strata of the north of Northumberland being here, and not in the Upper Coal Measures, which only exist in the south of the county. Intercalated with these shales are found, besides coal, beds of ironstone, and it is in the lower sequence of these beds—

the Melmerby Scar series—that the coal is worked in the north of Northumberland.

But, still further north, in Scotland, the Carboniferous sequence is well understood, and in the neighbourhood of Glasgow, at the bottom of the Coal Measures, are some beds of sandstone which are called "Millstone Grit," because they occur in this position. Below this are three principal beds of limestone, the lowest of which is called the Index Limestone. It is important, because the main coals and the Black-band ironstones lie underneath it, in Lanarkshire. The highest bed is called the Linnspout Limestone; and both beds have various other names in different localities, and I can assure you, if you looked at the ironstones and the fossils they contain you would think you were in the Upper Coal Measures of some of the midland counties of England. The fossils, too, are identical, though lying beneath the Marine series. Beneath these black-band ironstones and coals are another series of limestones, and below these there is met with a very great thickness of rock which belongs to the Calciferous Sandstone series. They are called the Beith Limestones, and are totally different from what are found in the greater part of England, or in Ireland.

I have now given types of the different series of Carboniferous rocks as we find them in Great Britain. If we go to Ireland we find very much like what we see in central England. There is a great mass of limestone divided in places by bands of shale; but beyond that is a series of black shales which contain fossils similar to those at Marsden; and at the top of that the Irish Coal Measures. In the Ballycastle coalfield, in the north of Antrim, the same type of things is to be seen which occurs in the Ayrshire and Lanarkshire coalfields; the marine bands being low down, with the coals in them.

If my point, that the black shales of central England are not equivalent to the Yoredale series, is correct, what are they? That is a question which can only be answered by an appeal to Palæontology; and, as I am going to appeal to Palæontology to clinch the stratigraphical argument which I place before you, I will take it a little later on. Let me just indicate the Palæontology of the subject. When we examine the beds of limestone which occur in the Upper and Lower Carboniferous series of Scotland, we find a number of marine fossils—*Productus*, *Spirifer*, corals, &c.,—just the same sort of things that occur so frequently in the Carboniferous Limestone; but we find many others which do not occur there. We find those shells which would be expected to be met with in rather shallower and brackish waters in sub-littoral situations. There are species of *Nucula* and *Nuculina*, shells which we find in estuarine basins; they inhabit mud rather than the clear sea of the limestone. So we are brought to the conclusion, which is a fact undeniable, that while these beds were being deposited, that part of Britain was much nearer to the land than was the Carboniferous Limestone of Derbyshire for the greater part of the time during which the mass of it was deposited. That it possesses so many littoral forms is largely in favour of that view.

In the Beith Limestones we have similar conditions, not, as in Derbyshire, one long sequence of deposit, in a sea of fairly uniform depth, and where the animals could go on living uninterruptedly, but a continual change of conditions, and a continual change of level. When the muds were brought down by rivers,—by floods or by change of level,—these animals died out, and we find a totally different fauna in the shales from what we have in the limestones. In the limestones we have comparatively the same fauna as in the limestones of Derbyshire; in the shales between, we have

a distinctly marine fauna, as the animals were again those which liked shallow water and would live in the muds. In the Middle Carboniferous series of Scotland, there is a condition of things totally different, marine life stopped altogether while the whole of the lower coal and ironstones were being deposited, and these ironstones are closely like those found in our Upper Coal Measures in England.

I attribute very great importance to the fact that all these limestones, and those of the Yoredale series of Wensleydale, and also those at Alston Moor, all contain right up to the top, corals, *Productus*, *Spirifer*, and the other fossils which are found in the Mountain Limestone, and these not dwarfed but very well grown indeed, as is well illustrated by this large *Lithostrotion* which came from the Main Limestone at Alston Moor. This limestone contains also very large Cephalopods. I measured an Orthoceras three feet long, and the base could not have been less than four or five inches across; so it shows there was no dwarfing of the species in these upper limestone beds at all. In Wensleydale the fauna does not change until we pass from the top limestone to the Millstone Grit. All the other limestones below the Millstone Grit contain the same species, one and all; there is no essential difference in their palæontological contents. Now, it is an axiom in Geology, that beds which have the same fauna should not be subdivided into main divisions; but here we have the Carboniferous System divided into two main divisions—the Carboniferous Limestone and the Yoredale series which contain an identical fauna. I am not aware of any one shell which is contained in the Yoredale series of north Yorkshire which is not also contained in the Carboniferous Limestone series of Derbyshire. There is no evidence whatever to divide them on palæontological lines; the fossil contents of the two series are identical.

We find there is a remarkable break in the fauna directly the top of the limestone is reached. The limestone fossils fail, and we get a series of fossils characterised by certain species of which I asked Messrs. Barnes and Holroyd to bring specimens this afternoon—Goniatites (*G. carbonarius* and *G. Listeri*) *Aviculopecten papyraceus*, and *Posidoniella lævis*—from the Coal Measures of Halifax, and which occur equally in the black shales and throughout that series of beds which have been called Yoredale, in South Yorkshire and Derbyshire—not so well grown, but still the same species—and this peculiar fauna, occurring in the shales of Marsden, amongst other localities, passes up into the Millstone Grit series. It therefore affords strong evidence of the true position of these shales, which have always been called "Yoredales."

From the palæontological point of view these shales have an identical fauna with the marine fauna of the Millstone Grit and Gannister series. The series was deposited under two totally different conditions—under fresh water and marine conditions—and therefore we find two different faunas; but the marine fauna keeps occurring again and again right up into the Third Grit, and also into the Gannister or Lower Coal Measures.

There is a very marked horizon of marine fauna underneath the Third Grit, from which I have collected a great number of fossils in various places. We find them in Cheshire, at Congleton Edge, and also at Pule Hill and at Marsden. The latter fact is mentioned in papers contributed to this Society by Messrs. Barnes and Holroyd. Last year I had the opportunity, through a grant of the British Association, of examining a series of fossiliferous beds exposed in making a reservoir, near Leeds. The same marine deposit was cut into. But as we trace this

series of beds north it seems to be like a lozenge, because although in North Staffordshire we get about 2000 feet, very soon north of Pendle Hill it passes up again and wedges out altogether, and we can only trace about 120 feet of it when we get into north Yorkshire. Pendle Hill seems to have been the place of largest development. *Aviculopecten papyraceus* occurs throughout the whole of this series in the marine beds, and goes up into the Gannister series of the Lower Coal Measures. Why, because we have a series of sandstones, or grits, make a break when there is no real palæontological break? There is no real palæontological break, because we cannot draw any true line between the Millstone Grits and the grits in the Yoredale series. It only means that the whole thing has been badly divided, and that the Millstone Grit series should go down to the bottom till it rests on the Carboniferous Limestone series. My own belief is that here we have been utterly wrong in calling the series of black shales and the thin blue heavy limestone which intervenes between the Millstone Grits and the Carboniferous Limestone "Yoredales." They have not the lithological characteristics nor the fauna of the typical Yoredale series, nor are they on the same horizon, because they are altogether above the Yoredale series.

I now pass on to the second part of my subject. It is difficult to have to compress the whole of the Geology of the Carboniferous System of Europe into short space, but I must give a sketch of what can be made out of the correlation of the British Carboniferous rocks with the same series on the Continent. There are two well-known series in Europe, the Russian and the Belgian; both are very distinct. In company with your late President, Mr. Stirrup, I visited last year some sections of the Carboniferous Limestone series of Russia, and I was struck with the great difference this series presents from what

obtains in Great Britain. On entering a Russian Carboniferous Limestone quarry one is struck by its appearance; it looks white like a chalk quarry. The Russian beds are very little disturbed indeed. They are nearly all horizontal, well bedded, perfectly white, and contain bands of flints which look like Chalk Flints. These flints are yellowish red and variegated. But for the simple fact that these Carboniferous Limestone flints contain Carboniferous Limestone fossils, I would not undertake to say, if shown one, whether it was from the Carboniferous Limestone or from the Chalk.

They do not seem to have in Russia any Upper Coal Measures at all, nor any representatives of our Millstone Grit series. The Russian palæontologists divide their Carboniferous Series into a three-fold division, which they maintain is hard and fast. There is the upper division, characterised by *Productus cora* and *Spirifer fasciger*. With regard to the latter British palæontologists say it is simply *S. duplicicosta*, which we find in the Mountain Limestone of Great Britain. Both the upper and middle beds are characterised by a series of organisms that we do not find in our Carboniferous Limestone. The specimen which I will pass round is made up of a mass of small organisms, *Fusulina* and others, which we do not seem to get in England at all. In the valley of the Don sometimes beds of coal occur—plant beds such as we have in our own Coal Measures—and then marine beds with characteristic Mountain Limestone fossils. The limestones do not form one mass. Then there is a fairly compact series round Moscow, characterised by *Spirifer mosquensis*. Although this species has been recorded as occurring in England, I am certain it is not found here at all—the one figured specimen bearing that name has been lost or mislaid, and having carefully examined all the other quoted specimens I can say that I have never seen the species from Great Britain. If any one discovers *Spirifer*

mosquensis in Britain it will be a great discovery. These beds also contain *Fusulina* and other small things. Then at the base there is another series which in the Ural mountains contains coal; this is characterised by *Productus giganteus*. That is a characteristic British species; and I want to lay great stress on this fact, that in Russia *Productus giganteus* does not occur in that part of the limestone where *Spirifer mosquensis* occurs; and *Spirifer mosquensis* does not occur where *Productus cora* occurs. If the Russian palæontologists are absolutely correct in this three-fold division, then the Carboniferous Series of England cannot be divided in this sense, because *Productus giganteus* occurs from the base of the Carboniferous Limestone up to the topmost limestone of the Yoredale series of Wensleydale; in fact one of the top limestones is called the "cockle limestone"; and in a part of that marvellous beach-bed described by Messrs Barnes and Holroyd, where that bed occurs at Waterhouses, in Staffordshire, there are hundreds of *Productus giganteus*, showing that in England this species occurs from the bottom to the top of the Carboniferous Limestone. Now *Spirifer mosquensis* does not seem to occur in Western Europe at all. It has been figured from the Belgian beds, but Professor De Koninck has unsaid all he did say on that subject. I perfectly agree with him that the things he mistook for *Spirifer mosquensis* were something altogether different; and that *Spirifer mosquensis* has not been known to occur in Belgium. But in Russia there are two genera of Brachiopoda which do not occur in Britain, but which do occur in the Himalayas and also in America—*Enteletes* and *Meekella*.

The Belgian geologists are not quite all of them agreed as to what is the real sequence of the Carboniferous rocks in Belgium. Professor Dupont, of the Brussels Museum, and the late Professor De Koninck thought there was a three-

fold division also occurring in Belgium—the Viséan, the Waulsortian, and the Tournaisian.

The Upper or Visé division was characterised by *Productus giganteus*, which we see is the opposite to that which occurs in Russia. The lowest Russian division was supposed to be characterised by *Productus giganteus;* the uppermost division in Belgium there is no doubt at all is characterised by that species. The second division is denied by the Geological Survey of Belgium. They say the division of Waulsort is only the local facies of the division of Visé. But in the division of Tournay *Productus giganteus* does not occur, whilst *Spirifer cinctus* and others do.

Now can we divide our Carboniferous Limestone into this three-fold division? I say No, we cannot; because if we take the fauna as found at Tournay and the fauna at Visé, and compare them, we find the majority of the species which occur at Tournay occur all through the Carboniferous series of England. So, granted the Belgian geologists are correct in stating that *Productus giganteus* had a very limited existence in their area only towards the upper or terminal portion of the deposit of the Belgian Carboniferous Limestone, that shell was in existence during the whole of the deposit of the British Carboniferous Limestone; and there may have been an extension later on towards Belgium, from England, of this sea, and therefore that this animal was able to migrate and live there only during the later portion. But the curious point is this, that nearly all the other fossils associated with those found at Tournay, Visé, and Waulsort occur together at Dovedale, Castleton, and in the Carboniferous deposits generally of Derbyshire.

This is not satisfactory, as far as we are concerned, because it shows that we are not able to work on the same lines as they do on the Continent. What we do find to

occur in Great Britain is this: in the whole of the beds of what are called the Yoredale series in north Yorkshire, and in the Carboniferous Limestone, the characteristic fossil is *Productus giganteus*. In the beds below (the Calciferous Sandstones) this fossil is not found at all. We never find it below the Limestone Series, but we find some peculiar fossils, one of which is *Modiola Macadamii*. This has been said to occur in the Coal Measures of Dewsbury, I think on Mr. Binney's authority. Now the true *Modiola Macadamii* is totally different from the shell which occurs at Dewsbury. The shell there is *Anthracomya Phillipsii*. *Modiola Macadamii*, discovered first in the north of Ireland, is never found above the top of the Calciferous Sandstone series.

Then there is a zone in which occurs *Productus giganteus*, and that goes right through the limestone of Derbyshire and the Yoredale beds of Wensleydale; and after that there is another zone, the zone of *Aviculopecten papyraceus*, and those big Goniatites—*Gastrioceras carbonarius*—occur near the base and go right up into the Gannister series. Then come the Coal Measures, characterised by *Carbonicola aquilina*, and at the top of this the Upper Coal Measures or the red beds, sometimes mapped as Permian, in which is found *Anthracomya Phillipsii*.

Now those are the zones we find in Great Britain. They are to be found in Ireland, and in Scotland, no matter how the beds are sub-divided; so that we have in this country a long period during which *Productus giganteus* lived—much longer than the period in which it lived in Belgium or in Russia. All these points will help, no doubt, in the future, in establishing the physiography of the Carboniferous period. It is no use trying to establish it in England alone. We want to know what was going on in Belgium and in Russia while the beds were being laid down here. We are

learning this little by little, and beginning to find some indications of what has happened. We find a very much longer period existed in England while *Productus giganteus* lived than while it lived in Russia and Belgium. Now we know this, too, that in England our Carboniferous Limestone series is not a pure limestone series, because we have so much sand and shale intercalated with it in some places. What does that mean? Limestone is purely an organic product—a product of animal life; the sandstones and shales are detrital products, the result of a wearing down of the earth. It means that we were nearer some land, or nearer the top of the sea when we had these beds laid down, than when we had the Carboniferous Limestone laid down.

We come, then, to this conclusion, that we were, in Scotland and the north of England, on the very edge of the Carboniferous sea which was laying down this material; and I doubt, if we went far north-west of Great Britain, if we should get any of the Carboniferous series at all.

The same sort of thing is seen in Devonshire, although there I am at variance with many geologists. I believe the black beds in the north of Devonshire were also laid down near to the shore. So, little by little, I hope we shall be able, in a short time, to break up this big zone of *Productus giganteus*, and to strike a line which (and I have nearly sufficient evidence to do it) will come right through the middle of the Yoredale beds and through the Carboniferous Limestone of Derbyshire. I have traced one big shell down nearly the whole way. Its life history seems to be limited to a few feet of limestone, and I am bringing it down each month further and further south. It was only last year I was able to bring it down from Scotland into Yorkshire. This year I have been able to trace it to the Isle of Man and to North Wales, and last week I got a specimen from

Derbyshire, which I think will enable us to draw a very good datum or zonal line through the middle of this series; and we shall find that the proper way of describing our Carboniferous series will be like this :—

UPPER DIVISION. { Coal Measures.
Millstone Grit.

LOWER DIVISION.—Carboniferous Limestone.

From Derbyshire, as we go north, the limestone splits up; the Great Scar Limestone only represents part of the Carboniferous Limestone of Derbyshire, but the Great Scar Limestone plus the Yoredale series of Wensleydale does represent the Carboniferous Limestone of Derbyshire. This forms the lower division, to which must be added the Calciferous Sandstone series of the North.

Mr. BARNES proposed a vote of thanks to Dr. Wheelton Hind for his very interesting address, with the greater part of which he was practically in agreement.

Mr. MARK STIRRUP seconded the motion.

Mr. HOLROYD: I am extremely pleased that we have Dr. Hind amongst us and that he has given us such a lucid explanation of the various sequences of the Carboniferous series, not only in England but on the Continent. I ought, perhaps, first of all to run over the various groups of fossils which are represented on the table. These comprise specimens from the following beds:—1. Roof of the Bullion Coal seam at Sholver, showing *Goniatites Listeri*, *G. carbonarius*, *Othoceras* of several species, *Aviculopecten* and *Posidonia*. 2. The shales above the Fourth Grit, from Holt Head, which contain *Edmondia*, *Schizodus*, *Bellerophon* and other small Gasteropoda. 3. The Millstone Grit of Netherley, showing a number of Gasteropoda, *Pleurotomaria*, *Loxonema*,

Murchisonia, Bellerophon Urii, B. hiulcus, Myalina Flemmingi, M. Verneuilli, Sedgwickia attenuata, &c. 4. The Millstone Grit of Evesham and Sawley near Ripon, containing *Nautilus tuberculatus, Streptorhynchus, Productus* (?) and a number of small Gasteropoda, indicating a Carboniferous Limestone fauna. 5. The shales of Marsden—*G. reticulatus, Ariculopecten,* ferns, *Posidonia, Myalina peralata,* and a number of small Gasteropoda. 6. *Producti* from Warlow Brook at Onecote.

We must, I think, all agree that after the lucid explanation of the stratigraphical arrangement of the Carboniferous series and the palæontological remains found therein, that Dr. Hind has made out a very good case for some revision of the chief groups of the Carboniferous System, but of what the new nomenclature is to consist it is very difficult to say. On broad lines a binary division would appear to be compatible with all requirements—1st of the coal-bearing strata, secondly of the great calcareous deposits, each characterised by its own flora and fauna. In Britain, however, the formations are not so easily disposed of. I understood Dr. Hind to say that in Derbyshire we had these so-called Yoredale shales—Millstone Grit shales if you like—resting clearly on the top of the Mountain Limestone. So far as I know that is not so, because in the first place we have never yet seen clearly to the bottom of the Mam Tor shales.

Mr. Barnes: Oh yes, we have.

Mr. Holroyd: At all events not underneath Mam Tor *in situ.*

Mr. Barnes: Not very far away. I have seen it, and Dr. Hind has also seen it.

Mr. Holroyd: Some years ago, when Castleton was stirring itself up on account of the new railway having been made, extensive building operations were carried on at the

Peveril Hotel. In digging out the foundations, 20ft. or 25ft. deep, they cut into what appeared to me to be fine-grained Yoredale shales, exactly similar to those in Wensleydale, and also similar to those I have seen round Bolton Abbey Station, and not of the nature of the Millstone Grit shales, but containing a suite of Mountain Limestone fossils. The fauna was Mountain Limestone entirely. The black shales had nothing in them to show that they had any connection with the shales underlying the Millstone Grits; so there, at all events, we have the top of the Mountain Limestone terminating in a series which seemed to be equivalent to the Yoredales. We can find them too in the quarry at Pindale. Then take what is commonly called the Kinderscout Grit. We have always been given to suppose that the Millstone Grit terminated with the base of the Kinderscout Grit; but at Pendle Hill the survey has found out a Fifth Grit; and between the bottom of the Kinderscout Grit and this Fifth Grit there is a bed of shales and another bed of grit; then at the top of Pendle Hill comes the Pendleside Limestone, 350ft. thick. I should like to ask what we are to do with that?

Dr. HIND: Have you seen it?

Mr. HOLROYD: I have. It is said to be 350ft. thick; and below it there are some 2,500ft. of shales, which are said to be the equivalent of the shales below the Millstone Grit of Marsden. Now the fossils found in these shales that lie on the top of the Mountain Limestone are the fossils characteristic of the Lower Coal Measures; and the fossils of the Pendleside Limestone are those of the Mountain Limestone below. So that here we have a Coal Measure fauna and flora in the shales and a Carboniferous fauna in the limestone. Are we to put this Pendleside Limestone along with the Mountain Limestone; or these shales along with the shales below the Millstone Grit? Then, again, we have had

pointed out to us—and on a great many of these points I am in entire agreement with Dr. Hind—that in the Yoredales at Alston Moor, and in north Yorkshire chert is found. It occurs also near the top of the Mountain Limstone; and we find chert in the beds I have been describing under the Peveril Castle Hotel, which seems to bear out my argument that these are the representatives, at Castleton, of the true Yoredale shales of Wensleydale. I am not aware that any chert has ever been found in the shales below the Millstone Grit. The question arises: what shall we call the Yoredale Shales? Shall we call them simply an extension of the Lower Coal Measures? Shall we regard the whole series from the top of the Coal Measures down to the top of the true Yoredale Shales as being Lower Coal Measure grits and shales? They are not certainly true Yoredale Shales. After all that can be said about it the Carboniferous system is only one; and all these distinctions and names which we give to different portions are only arbitrary, and not suited to all localities. It would certainly appear that the best classification is that which is based, as Dr. Hind has said, upon ascertained palæontological facts.

Mr. STIRRUP: I am very glad Dr. Hind has brought before us so strongly the palæontological side of the argument in stratigraphy, because I believe myself that there is no other guide so valuable in arranging these beds, in time and space; and I think he has also shown clearly that we must look on the Carboniferous series as a continuous sequence of deposits, and not as a heterogeneous mass of materials without any connection. Although we may not find the whole of the series developed in one locality, still we do find them in the same order of succession as a rule. If we take a wide view of the case we shall be able, I think—as Dr. Hind is doing—to bring into a clearer view the proper order and divisions of this great series of rocks, marine and

terrestrial. I think we already know that the Yorkshire coalfield and the Lancashire coalfield have been at one time united, and that we may find exactly the same fossils at Halifax, in corresponding strata, as are found in the Rossendale valley, in east Lancashire. Again, if we go to Belgium we find there similiar fossils, but I do not think the Belgian deposits are sufficiently well worked out at present to put the series in the same definite order assigned to them here. But Dr. Stainier has recently, in the Belgian coalfield found shells so remarkable as the *Goniatites Listeri* and the *G. diadema* encased in calcareous nodules similar to the limestone nodules or "bullions" found in the Bullion or Upper Foot Mine of the Lower Coal Measures of Lancashire. How far these Belgian deposits can be correlated with those of our English coalfields is not very clear at present, as the fossils referred to occur in what is called their Upper coals, as well as in a lower series. The ground in Belgium is much more broken up and faulted than in some of our English coalfields, therefore adding difficulties to the tracing of a correct sequence of the beds. We have been interested to hear that Dr. Hind has been able to visit a portion of the Carboniferous rocks of Central Russia and to show us where they resemble and where they differ from our own. It is instructive to have heard Dr. Hind's exposition of his by no means finished work.

Mr. ROBERT LAW, F.G.S., said: We have always been accustomed to give the name Yoredale to a well-known series of strata, and we shall perhaps continue to do so for some time to come. It is not very easy to eradicate names which have obtained a place in all geological literature. With most of what Dr. Hind has said I agree.

Dr. HIND, in replying, said: I am much obliged to you for the way in which you have received my address. Much I would like to have said has been necessarily left out. I

may have made a great deal of the palæontological side, but I hope I also made a good deal of the stratigraphical. I made my point from the stratigraphical before I touched the palæontological.

Mr. Holroyd wants to have, in a geological sense, a great deal we cannot give him; he wants everything absolutely certain—a species to die out and never to come in again. He says certain species of Lower Carboniferous facies come in in the Marsden beds; I also say they come back into the coal beds of Staffordshire, a much higher horizon. We get there many of these marine forms, but they are dwarfed. But I did not burn my bridge of boats. I meant you to understand that the times in which the Carboniferous deposits were going on in Russia, Belgium, and England were not the same, because the same species did not occur; because, when the epoch finished in one place marine conditions were going on somewhere else. Then after a long series of beds had been deposited the land sank, there was a slight migration back again, bringing a return of certain marine species, which began to establish themselves, and thus we have a thin marine band with a few species of a lower palæontological facies. There is no doubt whatever that the Carboniferous deposits of Great Britain are a continuous series; there is no unconformity of any moment—and that is one of the great difficulties in establishing subdivisions. The other difficulty is, as I said, that we, in England, happen to be on the edge of the basin in which these beds were deposited, and we get portions laid down under marine, lacustrine, and land conditions. At one time marine conditions lasted a long time; at another place only a short time. This we may say shows that there must have been a rise and fall of the land in a short distance. Well, if the stratagraphical evidence says so we must accept the facts. Mr. Holroyd says there are representations of these

Yoredale Shales in Derbyshire. Well, the break between the Carboniferous Limestone and these Millstone Grit shales is not always absolutely sudden and sharp. There are passage beds sometimes. At the base of Mam Tor these passage beds are absent. Generally there is a series of them, as at the Tissington railway cutting, where they are well exposed, and where the shales are contorted. I think the maps of the Geological Survey which show the whole of the Carboniferous Limestone area of Derbyshire and Staffordshire surrounded by faults are wrong. Where there is a thin series of fissile shales they fall over and are crumpled up. Over and over again, at the edge of the Carboniferous Limestone, we find the shales crumpled up; and the same thing, I believe, has gone on in the series on Pendle Hill. We have there a repetition of beds, but the Goniatites and other fossil remains of the series are peculiar.

This concluded the business before the meeting.

EVENING MEETING.

A SPECIAL MEETING of the Members was held on Friday Evening, December 16th, 1898, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. C. R. LINDSEY exhibited by means of the lime-light, and briefly described, the series of Geological Photographs referred to on pages 88 and 93.

At the conclusion of the meeting a hope was expressed that a similiar collection of prints, especially of those having reference to this district, might be formed by the Society. Several were promised at the meeting, and the Secretaries will be glad to receive copies from members, or others who are able to contribute.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IV. VOL. XXVI. SESSION 1898-99.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, January 13th, 1899, in the Mining School, Wigan.

Mr. W. S. BARRETT in the Chair.

NEW MEMBERS.

The following gentlemen, who had been duly nominated, were elected Ordinary Members of the Society :—

Mr. JOSHUA HAMPSON, 31, Bellot Street, Cheetham, Manchester.

Mr. JOHN GOODWIN, Flattocks, Castleton, near Manchester.

Mr. DAVID HOLLINGWORTH, 29, Cumberland Street, Lower Broughton.

Mr. JOHN B. SELBY, Atherton House, Leigh, Lancashire.

Mr. ALFRED SHAW, Bersham Colliery, Wrexham.

Mr. JAMES KEEN read the following paper "On Sinking two Shafts through heavily-watered Strata at Maypole Colliery, Abram, near Wigan."

DESCRIPTION OF SINKING TWO SHAFTS THROUGH HEAVILY-WATERED STRATA AT MAYPOLE COLLIERY, ABRAM, NEAR WIGAN, FOR THE MOSS HALL COAL COMPANY, LIMITED, WIGAN.

By Mr. James Keen.

Before commencing to give you a description of the work done in sinking the Maypole Pits, I should like to say a few words as to why we decided to put down such very powerful pumping plant, and our reasons for taking the precautions we did for dealing with a large volume of water. I don't suppose anything except our knowledge that there was a very large area of the celebrated Abram Cannel to be worked (providing the pits could be sunk successfully), would have led us to undertake the task. Most of you present know something about the value of this Cannel. I may say that this Cannel gives, per ton, the following results on analysis: 14,111 cu. ft. of 39 candle gas, with a large percentage of valuable residuals, and about 7 cwts. of good coke, and it must therefore always hold a foremost place for gas enrichment.

Some thirty years ago an attempt was made to sink two pits in the estate, but owing to the large volume of water found the undertaking was abandoned, and the pits filled up. After we had been pumping about 12 months, the farmer on whose land the old pits were situated called my attention to the sudden subsidence of one of them, the ground where the pits were had sunk 2 ft. below the surrounding surface; no doubt this was owing to our having

drained the water out of the pit. This was nearly one mile from our new pits. Another attempt was made about 24 years ago, by another company, to sink to these valuable mines, about 700 yards from our sinking, and about 40 yards on the deep of ours. After pumping at the water found in the top red sandstone for several years they got through this, but as soon as they came to the brown-red sandstone below the Permian Marls, they found such a volume of water that they abandoned the undertaking, and the pit now stands with 100 yards of water in it. It is about 51 yards from the surface, and I think it runs to us at this level.

Before commencing to sink we put down several boreholes in different parts of our royalties, two being to the first seam of coal. We decided to sink within 50 yards of one of these boreholes; the Red Sandstone was passed through at 150 yards, and the sinking afterwards proved how very accurate the boring was in giving a correct account of the strata passed through. We used the diamond drills, which brought out a core of the strata. The estates from which we are about to work the mines are surrounded by collieries at present working, and they have no water at any of these pits, so that the water we have met with can only be in the area we are going to work; this area is thrown down on all sides by large faults, so that it is entirely covered with red sandstone, which is not the case at the adjoining collieries.

When we commenced sinking we thought we should have a large quantity of water in the top band of red sandstone, which we passed through at 55 yards; then we had about 15 yards of red sandstone intermixed with red metal, which contained water, but we never had above 14,000 gallons per hour down to this depth, and I attribute this to

the fact of the former Company having pumped these strata partly dry, as during several years they were pumping enormous volumes of water with very powerful machinery, and as soon as they got through the Permian Marls to the brown red sandstone they tapped so much water that they abandoned the work.

I think this conclusively proves that no surface feeders get through the 24 yards of strong clay of which our top is composed, and all the evidence of our sinking goes to prove that the water we have been pumping during the last three or four years has had no surface feeder. After getting through the red marls at 113 yards, we came upon a large feeder, and as we went on sinking we came upon further feeders, always in floors. We never found any feeders from vertical fissures, and after pumping for a time they became smaller, and finally ceased. So that to-day we have practically no water except what comes from a floor where the Red Sandstone lies upon the Coal Measures. This feeder when first found was about 90,000 gallons per hour, but it has gone slowly less, and is now only about 60,000 gallons per hour. The water found below the red marls we have had analysed several times, and it always shews the same result. I herewith give copy of analysis by W. J. Orsman, F.I.C., F.C.S. :—

"Colour in a tube 2 ft. long—faint greenish blue.
Suspended matter—nil.
Smell when heated to 100° Fahr.—nil.
Taste—slightly saline.
Hardness before boiling 5°,—do after 1·4°.
Total solid matter—44 grains per gallon.
Loss on ignition, not deducting carbonic acid—11 grains per gallon.

Total mineral matter—33 grains per gallon.
Chlorine = to 7 grains per gallon of sodium chloride.
Lead—nil. Copper—nil. Iron—nil.
Lime present as bicarbonate.
Magnesia—trace only.
Alkaline salts present as bicarbonate of soda.
Sulphuric acid.—As sulphates, trace only.
Phosphoric acid—nil.
Nitrogen.—As ammonia—nil.
" As albuminoid ammonia—0·01 part per million.
" As nitrates—nil.
Oxygen absorbed by organic matter from solution of permanganate of potash—at 80° Fahr. in 2 min. nil; in four hours, trace only.
Microscopical results—nil."

Any surface feeders, now that the volume of water is so much less, would naturally alter this analysis, but it has not been found to vary, and everything points to the water we have been pumping and are at present pumping, coming from a large underground pound. I am sorry that we did not have the water which we found in the top red sandstone analysed, as I feel sure this would have shewn a very different quality. In fact, the water pumped at the Ince District Council's Pumping Station at Golborn, which is on the edge of one of the estates under which we have the mines on lease, is very hard, and on boiling, leaves a very thick deposit. I may just mention here that the reason we decided to pump the water instead of tubbing it back, was, that we had three or four valuable seams of coal so near to the sandstone that the breaking of the roof in working these mines would have brought the water into our workings.

The most striking features from a geological point of view to me were, first, the great difference we found in passing through the clay. At No. 1 Pit it went right down to the sandstone, but at No. 2 Pit, 50 yards away, we found at the bottom of the clay 13 feet of running sand, and 3000 gallons of water per hour coming right down to the top of the sandstone; some of it was exactly like the pebbly beach so often seen at the sea side. At about 120 yards we came upon a hard, bright, glittering looking sandstone, some of it having the appearance of rock salt, and a pick would scarcely touch it; it had a slight saline taste and after a few hours' exposure to the atmosphere it commenced to waste away, similar to ice thawing, and in a very short time a hole had run into the side of the shaft for 20 ft., 10 ft. wide by 15 ft. high; this had to be made secure as early as possible, otherwise very serious trouble would have occurred. We also found below this, at about 135 yards deep, a bed about 6 ft. thick containing round balls, from the size of a pea up to the size of a billiard ball, very hard, and perfectly round, which when put into the fire exploded and gave off a strong sulphurous smell. They are portions of the sandstone in which the grains are cemented together by iron pyrites, which seems to have been deposited round numerous centres. We also found in the Permian Marls a bed of flattened round calcareous concretions. We got to these a day or two before Christmas Day, and the sinkers called them "mince pies," which in shape they resembled very much.* We do not appear to have found many fossils except in the series of the Ince mines; in the metals between these various seams of coal, remains of various plants were very plentiful.

I propose now to describe the sinking of No. 1 Shaft. We commenced actual sinking operations on May 31st,

* Vol. XXV., p. 240.

1895, and laid the first bricking ring at 26 yards; the whole of this sinking was in strong clay, and we put in elm rings 6 inches square, and close timbered with battens 2 inches thick.

On July 2nd, 1895, we came to some water at 36 yards, and put in at that point a water ring; then went on for another three yards and found more water than we could wind and pursue sinking operations at the same time.

Sinking was suspended until a pump could be put to work; we applied a straight line sinking pump by Joseph Evans and Sons, of Wolverhampton, having a 7 inch ram and a 14 inch steam cylinder, with 24 inch stroke, equal to pumping 14,000 gallons per hour. This was slung in chains with large blocks for lowering. Sinking was resumed on September 25th, 1895, and we passed through the water at 64 yards, where a water ring was put in to catch the water, which amounted to 12,000 gallons an hour. We pumped out of a tank fixed at this point, the pump being fixed on a bearer, and from this depth we proceeded, getting through the red sandstone at 70 yards, after which we had red metal for 63 yards, and on January 8th, 1896, at the depth of 113 yards we came across another feeder of water.

Here we applied another straight line sinking pump, also by Evans, with steam cylinders 24 inches, rams 13 inches diameter, and 24 inch stroke. This pump is equal to 40,000 gallons per hour, running 35 strokes per minute, and when fully equipped with a column weighs over 25 tons. We slung this pump on steel rods, 3½ inches diameter, in 10 feet lengths, and lowered it with a screw 5½ inches diameter working through a worm and worm-wheel, by a pair of engines with cylinders of 8 inches. The pipes were all

made in 10 feet lengths, corresponding with the rods, and we lowered each time 10 feet; the slide on the suction of the pumps allowing of a movement of 12 feet.

Whilst sinking and using this apparatus we were enabled to lower the pump 10 feet in 25 minutes, which included stopping and starting. I draw special attention here to the fact that all the pipes used were of steel with the "Acme" joint; we have never had any trouble with them; there are some fixed now that have been fixed for two years; they are light, strong, and durable, and have had nothing done to them. To each of the large Evans pumps we have steam and exhaust pipes 5 inches diameter, and a rising main 9 inches. These pipes hang in the pit and swing about without having any injurious influence on the joints. To these pumps we constructed proper stages for the men in charge, and have always made it a rule never to have any of our pumps working without a man in charge, and I think this is of the highest importance in sinking operations.

We went on sinking to 117 yards, and tapped about 27,000 gallons of water per hour. Here we decided to make a pump-house and underground lodges for the large pumping engine. We commenced making the pump-house and lodge on the 17th March, 1896.

At the same time we decided to put in a pair of pumps by Pearns, of Manchester, at this depth, to supplement the Evans pumps. Whilst the lodge making was still in progress we started the Pearns pump on May 1st, 1896. It was of the duplex type. The rams were 10 inches diameter and the steam cylinders 24 inches diameter, the stroke being 18 inches. The pumping capacity of these Pearns pumps is 42,000 gallons per hour, running at 35

strokes per minute. On June 23rd, 1896, we started the large Hathorn-Davy ram pump, with engine on the surface, and ram 24 inches diameter, having a stroke of 10 feet. We went on sinking to a depth of 121 yards, and tapped a further quantity of water of 60,000 gallons per hour. This coming in so far below the fixed Pearns pumps that they could not deal with it, we put in a length of tubing made of boiler plates, with 18 inches cement brickwork and cement concrete backing, and so elevated the water 10 feet to a cistern. This enabled the Pearns pumps to deal with what was beyond the capacity of the Evans pumps.

It will readily be understood that we have had our share of pumping accidents, which are quite frequent in sinking operations. On the 2nd of July, 1896, the large Hathorn-Davy pump burst a clack-box cover, and, to prove that mishaps in pumping do not come alone, the Evans pump, by overwork, also failed, and the water flooded us, rising to within sixty yards of the surface. All the pumps were under water. We raised the Evans pump and added another of the same size, sustaining it with similar gear on the opposite side of the shaft, and were able to get to work again.

Sinking was resumed on July 27th, 1896, and continued until August 6th, when we tapped a further large feeder, which made the total quantity of water being pumped to the surface 160,000 gallons per hour. We put in a No. 11½ Pulsometer at this point to pump the water to the big pump, and fixed the two Evans pumps on bearers, as they work so much more satisfactorily at this depth when fixed than when slinging. Sinking ceased at No. 1 shaft and was not resumed until more than a year later, viz., November 12th, 1897, when we commenced sinking again at this pit, and passed through

the water exactly the same as we did in No. 2 Pit; put in the sealing ring, and as the pit is 7 or 8 yards on the deep of No. 2, we pump most of the water from behind the sealing ring in this pit. We have gone on sinking since November, 1897, but if we have had to stop for anything it has been this pit that we have let stand. To-day we are through the Ince mines, and within 40 yards of the Bickershaw 7 ft.

We commenced sinking the No. 2 Shaft on September 1st, 1895. It was suggested to me to sink through the clay without putting in the elm rings and battens, as explained in describing No. 1, but I preferred to run no risk, and have always held that it is unwise to do so, especially when it only saves a little labour.

As before mentioned the clay in No. 1 Shaft went right down to the rock. In No. 2 Pit at a depth of about 20 yards we came upon sand and pebbles, and down to about 26 yards we had a quicksand, with from two to three thousand gallons of water per hour. There was the greatest difficulty to keep the shaft right in passing through this treacherous ground, and I am satisfied that if we had not had the shaft close timbered from the surface it would certainly have been lost; even as it was, the whole of the timber from top to bottom moved, and we had to sling the whole of this timbering from the top with chains, attached to large balks put across the shaft each way. I had erected a large pair of winding engines to wind permanently from this pit, and had we lost it, it would have been a very serious matter. This has happened in two or three instances in this district. We got down to 29 yards, when we were stopped by water, although the ground appeared open and the No. 1 Shaft was only fifty yards away and had a considerably greater depth than this. We commenced sinking again on September 8th, 1896,

using the small Evans sinking pump that had been in use in the other shaft, as the water that this pump had been dealing with disappeared.

We proceeded to a depth of 115 yards, and finding more water commenced to drive a tunnel between the two shafts; this was completed and bricked on December 7th, 1896. We commenced sinking again on that date, and finding more water we put in a syphon 4 inches diameter through the tunnel, which enabled us to go on sinking until December 13th, 1896, down to a depth of 120 yards.

On this date the Hathorn-Davy pump burst its bottom clack-box, which resulted in the water rising up in the No. 1 Shaft to the Pearns pump. We raised the two Evans pumps up to the same level, and they all delivered the water to the surface; the water that these pumps could not deal with came through the tunnel into the No. 2 Shaft.

We commenced winding the water in the No. 2 Shaft on December 18th 1896, and up to January 10th, 1897, dealt in this way with an average of 47,000 gallons per hour without a break. The tank or barrel that we used held 1,010 gallons, having a clack 24 inches diameter in the bottom. During one experimental hour we wound 59,000 gallons of water, and I know of no other case in which so much water has been wound in the time from such a depth by a single barrel.

When the pumps had been got to work again, we almost immediately tapped further water in the No. 2 Shaft, and had to put in a Pulsometer pump No. 11½, the capacity guaranteed being 80,000 gallons per hour, against a vertical height of 70 feet with 60lbs. of steam pressure. On January 26th, 1897, at a depth of 123 yards, we found a

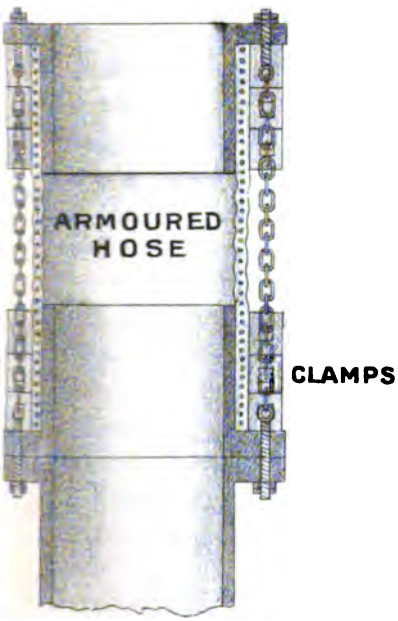
further large feeder, and put in another Pulsometer pump of the same size, both being hung by means of Elliott's "locked coil" ropes attached to steam capstans. The water now began to leave the No. 1 Pit, and had to be pumped through the tunnel to the Hathorn, Pearns, and Evans pumps.

Our greatest difficulty now was not with the Pulsometer pumps themselves, but with the suction pipes, which were of light cast-iron, and having this large quantity of water we were obliged to fire our shots while the suction pipe was actually in the bottom. The result was that we broke as many as three or four suction pipes in a week, and after considerable thought I had a flexible joint made something after the fashion of a short length of large fire-hose. *See Plate I.*

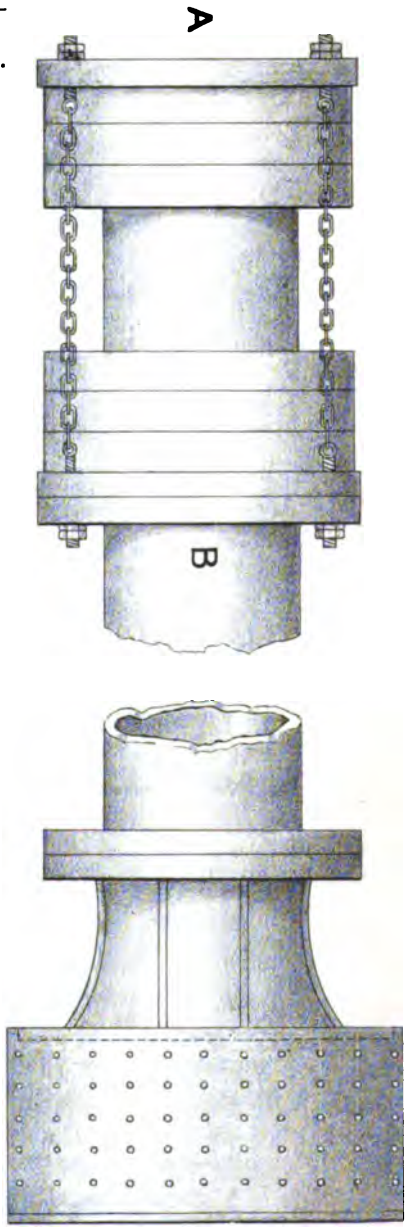
This was connected with the pumps above and the continuation of the suction pipe below and provided the needful elasticity, thus avoiding breakages from sudden shocks by shots. This joint has been an eminent success, and I strongly recommend it for any kind of sinking operations. The ordinary delivery and suction clacks did not give satisfaction, as they required too frequent renewal. We applied disc valves of rubber, and they have proved most successful. We went on sinking until March 27th, 1897, when we had reached a depth of 138 yards, and during the whole of this time we were constantly tapping fresh feeders below, but the feeders above either went less or followed us down. The water being pumped at this time was about 120,000 gallons per hour, practically all in this shaft. At each large feeder that we reached we put in water rings, and although we had twelve-inch flanges with seven-inch waterways, and as many as six outlets in them, they were insufficient to take the water.

Trans. Man. Geo. Soc. Part IV Vol. XXVI
To illustrate Mr. James Keen's paper.
On Sinking through heavily-watered Strata
at Maypole Colliery" Plate I

PUMP SUCTION
SHOWING FLEXIBLE JOINT.



SECTION ON A B.



SCALE 1 Inch = 1 Foot.

I may here refer to the great importance of making these rings thoroughly watertight, otherwise it is no use putting them in. My experience is that the best way to accomplish this is to lay them on oakum, and set the first six courses of bricks in cement and mortar; then grout the whole in with very good and fresh cement, and there will be no difficulty in making them tight. In no instance has the water passed any of our rings, although they have been put in with feeders flowing over them of sixty and seventy thousand gallons per hour. We have always had a dry pit, which is a very great advantage in every way. There are many who prefer to bed the rings in clay and puddle them, but the body of clay that can be got in is so small that it perishes, and consequently fails in its object. Two of the first rings which we put in the No. 1 Shaft were laid in this way, and although there is only a very small quantity of water near them, in both cases the water passed them, I think it well to explain here that we laid all our rings on solid beds; we had them 18 inches wide, and for about three feet above each ring we put in 18 inch brickwork, and as we came up from below with the next length of brickwork we cut the rock out, and thus got nine inch brickwork under the front of the ring. When this can be done it is much better than plugs to carry the ring.

On April 2nd, 1897, we found another feeder, and stationed the two Pulsometer pumps already in the shaft at this point, and put in tanks made of light steel plates to catch the water met with down to this point, and pumped it with these two Pulsometer pumps. We applied two more Pulsometers and fixed them on the ropes and went on sinking.

Keeping the bore-hole before us about twelve feet in advance, sinking proceeded to 146 yards comparatively dry,

but on April 18th, 1897, we tapped a further large feeder with the bore-hole at 150 yards deep. The water rushed up this bore-hole and rose like a fountain to an elevation of 26 feet above the top of the hole. We immediately plugged the hole. We also decided to put in another Pearns pump capable of delivering 70,000 gallons per hour to the surface. Locating this in an engine-house, we started it on August 8th, 1897. We had in the meantime bored about ten to twelve holes down to the feeder and tested the volume to be 90,000 gallons per hour. We went on pumping at this feeder, having the holes open whilst the Pearns pump was being fixed. We always had men to plug the holes up in case of any mishap with the pumps, and found the pressure was so far reduced when we resumed sinking that the water only rose about 8 feet above the bore-holes.

We also put one bore-hole down to a depth of 68 feet below the feeder, and found that we were in the Coal Measures, so that this large feeder was where the red sandstone joined the Coal Measures. To our great satisfaction we recognised that we were through the water-bearing strata, and at once decided to catch the water at this point, as we had ample pumping power to deal with it. On August 13th, 1897, we commenced sinking through this feeder, and at 152 yards deep we put in a sealing ring to enable us to take or stop the water at will, and had all completed and the scaffold out of the pit on September 11th, 1897.

After this we went on sinking with the water in the bottom until we had reached a depth of 156 yards, where we put in tanks, letting the water out from behind the tubbing with pipes 12 inches in diameter, and valves that we could regulate. We have frequently had these valves closed for a period of twelve hours, and have found the water no trouble to us. This arrangement was completed by the end of

September, 1897. Afterwards the sinking was comparatively free from difficulty, as it was all dry. By this term dry I mean we had all the water effectually caught, and there was none in the pit bottom or loose in the shaft, but was all being pumped from behind the tubbing or out of tanks. The quantity at this date (September, 1897) being pumped to the surface was from one hundred and sixty thousand to one hundred and seventy thousand gallons per hour. This maximum quantity has gone on diminishing, so that at the present time (January, 1899) we are not dealing with more than seventy thousand gallons per hour. I am even hopeful that there will still be a further substantial diminution. This shaft is now completed. As you will see by the section, we have passed through the Wigan 6 ft. mine, and are 21½ yards below it, and have commenced to prove the coal-field. The total depth of this shaft is 604 yards. We found the celebrated Abram Cannel at 562 yards, of excellent quality, 6 ft. 3 in. thick, with 1 ft. 7 in. of coal on the top of it. The whole of the mines passed through, as shown by the section, are above the average thickness and of good quality.

I think it would be well in this latter portion of my remarks to give my audience the benefit of the experience which this work has given me. There is an advantage in all important undertakings, that circumstances arise during the carrying out of the work, which, if properly appreciated, may be very useful in future undertakings of a similar character.

It will hardly be necessary for me to say to a strictly mining audience, chiefly composed of those who have charge of important mining work, that there should be no scamping in mining appliances, and that, especially in sinking operations, everything should be of the best. This should be

placed first and foremost in the interests of safety, because no amount of skill and care would prevent serious accidents if the appliances were defective. Everything that has to be used in sinking should be of the best quality, and so far as possible everything should be tested to a very much higher stress than it is intended to bear.

Not only should everything that has to be used in the way of lifting have a large margin for safety, but the whole of the pumping plant should be equal to at least double the work it will be called upon to do. It will have been noticed that the greatest volume of water with which we have had to deal is 170,000 gallons an hour, and it has been satisfactory to me to know that the pumping appliances at my command were nearly equal to double that amount. We had pumps equal to 310,000 gallons per hour from a depth of 120 yards. So far as practicable everything should be duplicated. I will mention a few of the most important:—(1) The steam pipes to the pumps from the boilers, as a blown-out joint in a large range of steam pipes might lose you the pit; you should certainly have two independent steam connections to your pumps; (2) duplicate boiler feed pumps; (3) duplicate pumps to your condensers for your pumping engines; (4) it is also very important to have valves at the surface to each set of steam pipes going to the pumps in the shafts, with signalling appliances, so that they can be closed immediately in cases of accident.

It is simply throwing money away to construct pit shafts which in any case entail an outlay of many thousands of pounds, with defective material. The brickwork should all be put in solid, and set in good mortar. Where water has to be contended with, the setting should be in lias lime. In no case should there be any backing to the brickwork, my experience being that such constructions always lead to

trouble by the brickwork giving way; and, above all, have good hard-burnt bricks.

The improvements in steel manufacture of recent years have greatly assisted important mining undertakings, and we are now able to make use of steel which, with a quarter of the weight, affords greater strength than the cast-iron arrangement that formerly prevailed. The advantages of diminishing the weight to such an extent will be understood. When you have to sling both pumps and pipes from the surface, and to raise and lower them daily, you will understand how necessary it is that they should be both light and strong—the pipes with joints that can be easily made, and not liable to give way. There are many makers of this class of pipes, but we used the pipes with the "Acme" joint, made by Edward Lewis, of Wolverhampton. Our large steel pipes from 20 to 26 inches were made by Messrs. Piggott and Co., of Birmingham. We found them both to answer well.

All the pumping plant named, with the exception of the surface Hathorn-Davy pump, is not intended as permanent plant. Most of the sinking pumps are not economical in the use of steam, and when you come to fix permanent plant you should, as far as possible, have the most economical. I must say, that in sinking, economy is not always the most important matter to consider, as you want the kind of pump that will go the longest without stopping, for at times stopping pumps with 2,500 gallons of water per minute in the pit, means disaster.

I now come more in detail to the question of pumps. We have used several kinds, first the Joseph Evans and Sons' Straightline Sinking Pump. These have done us good service, are strong and want little repairs, the clacks are

adapted to take any amount of sand, and they are ram pumps. Nothing but ram pumps would have been of any use to us with the sand we had to raise. Our various pumps at times have dealt with several tons of sand each 24 hours. Then we have the Frank Pearn and Co.'s Horizontal Duplex Pump with short stroke, and wherever you have large quantities of sand you want pumps with short stroke going quickly. We frequently run both Evans' and Pearns' pumps at 35 strokes per minute. This pump had valves that would also pass any amount of sand. Neither of these pumps wanted repairing very often, and this is a great consideration. Next comes the Pulsometer pump. I agreed to use this pump, only with a guarantee which has been more than fulfilled. By the vital principle of their action they must be light, which enables them to be easily handled, and as the steam used in forcing the water combines with and is delivered with the water, we avoid the trouble from exhaust steam which my audience knows to be very great. I do not hestitate to say that if I had to commence another sinking operation of this character to pass through a volume of water of 150,000 gallons an hour to a depth not exceeding 100 yards, I should use Pulsometer pumps alone for the pumping during sinking. I am satisfied that with the pressure of steam now easily available, Pulsometers would raise practically any volume of water to a vertical height approaching 100 feet, which would necessitate say, three different Pulsometers and different lifts. I would make my shafts large enough in diameter to provide room for these Pulsometers without interfering with the needful area in the shaft itself. Pulsometer pumps will deal with almost anything, and matter with which ordinary pumps find it impossible to deal does not hamper Pulsometer pumps at all. We had one pumping 30,000 gallons per hour against 107 feet head with 85lbs. of steam for months. In completing my remarks on

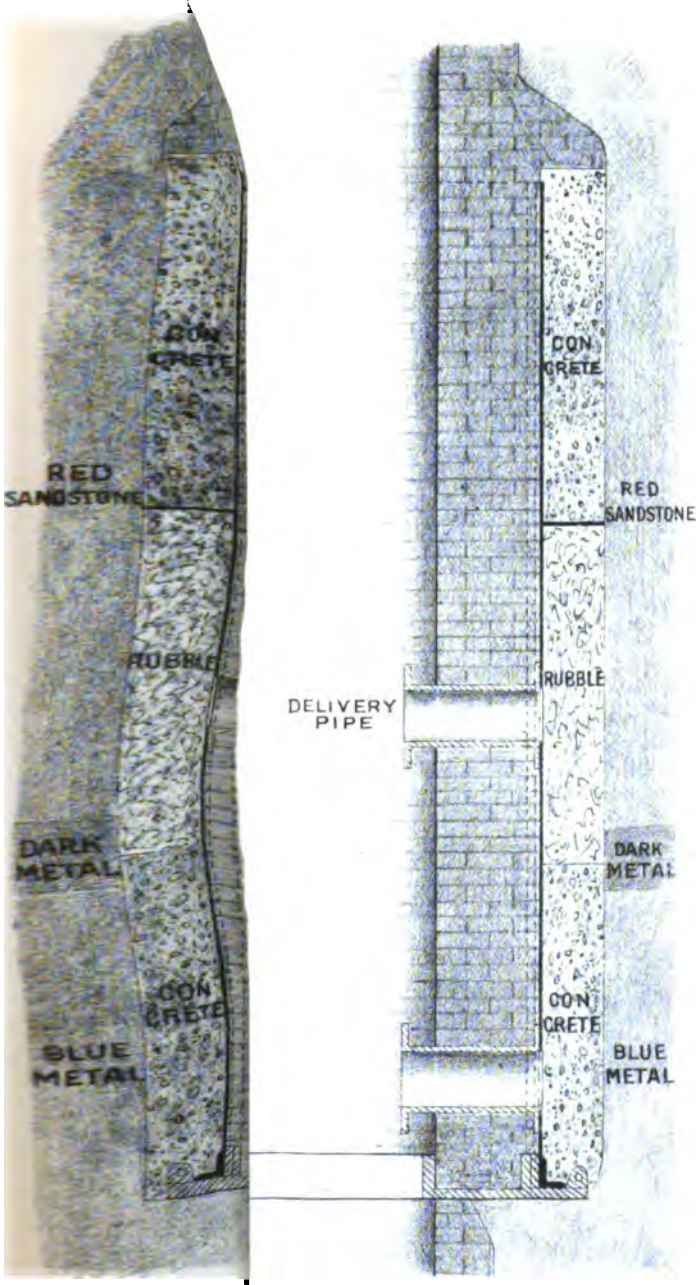
pumps I cannot speak too highly of the whole of the pumps we have used, but in matters of this kind you have to consider the quantity of water you may have, and the depth you will have to pump it from before you decide upon the pump to be used. Nothing but practical experience is of any use in these matters.

I have mentioned in a previous portion of my remarks, that whatever class of pumping appliances is in use, each separate pump should have a man constantly in charge. When pumps stop they take some time to re-start, and a man having hold of the steam valve can often prevent a pump from actual stoppage. If the work goes on smoothly he has little or nothing to do; so much the better; but in the event of mishaps so natural in sinking operations, the man is in attendance, and can prevent a disaster which might flood the entire shaft. In no case should pumps be left to the mercy of sinkers.

The diagrams which I have been able to use, I hope, have made it clear to my audience the method we adopted when reaching the bottom feeder, which was the largest feeder we met with, making 90,000 gallons per hour. I will briefly describe how this work was carried out. When we got through the sandstone we had hard white rock for some depth, and 8 feet above the feeder we commenced to widen out the shaft 2 feet 6 inches all round, and we took the shaft down this size to 6 feet under the feeder. There we got a perfect bed for a ring, the ring being cast-iron in eight segments, with a flange 6 inches deep in the front, and 19 inches from the front another flange the same size. This was laid on strong felt and grouted with cement. When this was made tight, we had a ring made of boiler plates 15 feet high, in two parts, the bottom part being 10 feet and the top part 5 feet. This was also in eight segments, each

segment having 2½ inch angle iron rivetted on it, with ¾-inch holes, 2½-inch centres, for bolting together, and angle iron riveted on the bottom, for it to stand on; with rings of 4-inch angle iron, having ¾-inch bolts, 2½-inch centres, bolting the upper and lower lengths together. The 10-feet length being put in first we had two 12-inch outlets at the bottom, and two other outlets 7 feet from the bottom, with 12½-inch pipes, 2 feet long, rivetted on. These segments were bolted together with India rubber strips to make the joints, and caulked with oakum at the bottom behind the flange on the ring and made perfectly water-tight; then a ring of 18-inch cement brickwork was built up to the top of the 10-feet ring, and each course grouted in with cement, then two blank flanges were put on the bottom pipes, and the water flowed out of the top pipes, the 10-inch at the back of the boiler plate ring being now filled in with concrete made of small broken bricks and cement. As each foot in height was done we ran cement down through 4-inch pipes, with funnels at the top, as thick as it would run all round. When this was done 6 feet high, we filled the next 3 feet up with broken bricks, about three pieces out of each brick. We then put some old boiler plate on the top of these bricks, and made all good with cement and concrete to the top of the 10-feet rings. We then put the 5-feet lengths of ring on the top of this, and bolted it together with rubber between the horizontal joint and the vertical joints, and took the 18 inch cement brickwork to the top of this. We filled the top length up with concrete in the same way that we did the bottom length, and took the brickwork up to the ring above. When this had been done we went on sinking. We had valves put upon the pipes, which when the pumps are at work, are open, and when from any cause the pumps are not at work these valves are closed, and we are able to keep the shaft perfectly dry. (*See Plate II.*)

Trans. Man. Geo. Soc. Part IV. Vol. XXVI.
To illustrate Mr. James Keen's paper.
On Sinking through heavily-watered Strata
at Maypole Colliery." Plate II.



The diameter of No. 1 Pit is 18 feet and that of No. 2 Pit 16 feet.

Such is my description of the sinkings at Maypole so far as they have progressed, and as they mean not only the passing through of the whole of the watery strata, but in one shaft a further distance of 200 yards has been accomplished, I think that the description fairly covers the work. We have been fortunate—for which I am exceedingly glad—in freedom from serious accidents. The particulars embodied in the section will supplement the remarks which I have been able to make and to which you have done me the honour to give so careful an attention.

MAYPOLE COLLIERY.

SECTION OF STRATA.

No. 2 Pit Shaft.

Description of Strata.	Thickness of Strata. Yds.	ft.	in.	Distance between Mines. Yds.	ft.	in.	Depth from Surface. Yds.	ft.	in.
Soil	0	1	0	....			....		
Clay	8	0	0	....			8	1	0
Clay	6	0	0	....			14	1	0
Sand on North Side	2	2	0	....			....		
Clay	5	1	2	....			19	2	2
Clay and Pebbles..	0	2	11½	....			20	2	1½
Sand on North Side..	0	2	0	....			....		
Sand and Pebbles..	1	0	9	....			21	2	10½
Very Fine Gravel	0	2	11½	....			22	2	10
Sand	3	1	5	....			26	1	3
Pebbles and Gravel	1	0	9	....			27	2	0
Red Sandstone	10	2	3	....			38	1	3
Do.	1	1	6	....			39	2	9
Do.	9	0	5	....			49	0	2
White Sandstone	0	0	2	....			49	0	4
Red Sandstone	1	0	6	....			50	0	10
Grey Sandstone, very soft ..	0	0	8	....			50	1	6
Red Sandstone	0	0	6	....			50	2	0
Do.	1	0	6	....			51	2	6
Red Sandy Metal..	7	1	6	....			59	1	0
Red Sandy Metal	1	0	6	....			60	1	6
Red Metal	0	1	6	....			61	0	0
Red Sandstone, with grey bands and metal partings	3	0	0	....			64	0	0
Red Metal	0	1	8	....			64	1	8
Red Sandy Metal, with grey bands	1	2	0	....			66	0	8

Description of Strata.	Thickness of Strata. Yds.	ft.	in.	Distance between Mines. Yds.	ft.	in.	Depth from Surface. Yds.	ft.	in.
Red Metal	1	0	0	....			67	0	8
Do. mottled	0	1	8	....			67	2	4
Red Metal..	1	1	4	....			69	0	8
Bluish Grey Metal	0	0	4	....			69	1	0
Red Metal..	1	0	2	....			70	1	2
Red Metal, with grey sandstone bands..	0	1	2	....			70	2	4
Red Metal..	0	1	0	....			71	0	4
Do.	0	0	3	....			71	0	7
Do. with grey bands ..	0	0	6	....			71	1	1
Red Metal	1	0	11	....			72	2	0
Do. with grey bands ..	0	0	6	....			72	2	6
Red Metal	1	0	5	....			73	2	11
Red Sandy Metal	3	2	11	....			77	2	10
Red Sandstone Rock	0	2	5	....			78	2	3
Red Sandy Metal	0	1	5	....			79	0	8
Red Rock, hard	0	2	9	....			80	0	5
Red and Blue Metal..	0	1	7	....			80	2	0
Red Sandstone Rock, very hard	0	1	0	....			81	0	0
Red Metal	0	0	2	....			81	0	2
Red Sandstone Rock, very hard	0	1	2	....			81	1	4
Red Sandy Metal	0	2	5	....			82	0	9
Red Sandstone Rock, hard	1	2	9	....			84	0	6
Red Metal, hard	1	1	3	....			85	1	9
Red Sandy Metal, hard	3	1	5	....			89	0	2
Red and Blue Metal..	0	0	8	....			89	0	10
Red Metal	2	1	11	....			91	2	9
Red and Blue Metal..	0	1	0	....			92	0	9
Red and Grey Rock, hard	0	2	5	....			93	0	2
Red Metal	0	0	10	....			93	1	0
Red Mottled Rock	0	0	4	....			93	1	4
Red Metal..	0	1	8	....			94	0	0
Do.	0	2	3	....			94	2	3
Red Metal, with blue and hard bands	5	1	7	....			100	0	10

Description of Strata.	Thickness of Strata. Yds.	ft.	in.	Distance between Mines. Yds.	ft.	in.	Depth from Surface. Yds.	ft.	in.
Red Metal, with blue bands....	0	1	8	....			100	2	6
Bluish Red Metal, with round flat fossils..	5	0	10	....			106	0	4
Red Metal..	0	2	0	....			106	2	4
Bluish Red Metal..	0	1	0	....			107	0	4
Bluish Grey Sandstone	0	0	3	....			107	0	7
Coarse Red Sandstone	4	0	3	....			111	0	10
Red Sandy Metal	0	2	0	....			111	2	10
Red Sandstone	2	1	7	....			114	1	5
Do.	3	0	0	....			117	1	5
Do.	1	0	1	....			118	1	6
Do.	3	0	0	....			121	1	6
Do. soft	0	2	2	....			122	0	8
Do.	1	1	8	....			123	2	4
Sandstone, coarse and soft	0	0	6	....			123	2	10
Sandstone, finer and a little harder	2	1	6	....			126	1	4
Red Sandstone	2	2	6	....			129	0	10
Do.	2	1	6	....			131	2	4
Do. with water	0	2	9	....			132	2	1
Soft Red Sandstone, with water	2	2	0	....			135	1	1
Sandstone, with water	1	2	0	....			137	0	1
Strong Brown Sandstone	0	1	0	....			137	1	1
Strong Brown and Grey Sandstone	2	0	0	....			139	1	1
Sulphur Pebble Bed	0	2	0	....			140	0	1
Coarse Red Sandstone, with water	1	0	3	....			141	0	4
Do. do. do.	1	0	9	....			142	1	1
White Sandstone, with hard sulphur bands	2	1	0	....			144	2	1
Variegated Sandstone, with sulphur bands	0	2	0	....			145	1	1
Variegated Sandstone, with sulphur bands	0	1	0	....			145	2	1

Description of Strata.	Thickness of Strata. Yds.	ft.	in.	Distance between Mines. Yds.	ft.	in.	Depth from Surface. Yds.	ft.	in.
Hard Brown Sandstone, with grey bands and water	1	0	0	....			146	2	1
Strong Red Sandstone Rock....	3	1	6	....			150	0	7
Bottom of Red Sandstone, last water	....			....			....		
Strong White or Grey Rock, with hematite floors..	2	2	6	....			153	0	1
Coal Measures :—									
Hard Grey Rock, with hematite partings	2	1	0	....			155	1	1
Hard Grey Rock	2	0	0	....			157	1	1
Strong Grey Rock	1	2	6	....			159	0	7
Blue Metal, coloured with red	1	0	0	....			160	0	7
Red Sandy Metal, with band of grey rock	4	1	3	....			164	1	10
Blue Metal, coloured with red and strong grey rock bands..	2	0	11	....			166	2	9
Blue Metal, strong, with grey rock bands	2	0	0	....			168	2	9
Blue Metal, with sandy rock bands	1	2	0	....			170	1	9
Blue Metal, coloured red	3	1	0	....			173	2	9
Blue Metal	1	0	0	....			174	2	9
Very Fine Fire Clay, soft	0	0	1	....			174	2	10
Fire Clay or Warrant	2	0	7	....			177	0	5
Blue Sandy Metal..	1	0	4	....			178	0	9
Sandy Metal mixed with red ..	1	0	8	....			179	1	5
Blue Metal, with iron hematite nodules	0	1	6	....			179	2	11
Strong Grey Metal, sandy, and coloured red	0	1	1	....			180	1	0
Strong Grey Sandy Metal	1	1	0	....			181	2	0
Blue Metal, with soft variegated stripes stained with red ..	7	1	0	....			189	0	0

Description of Strata.	Thickness of Strata. Yds.	ft.	in.	Distance between Mines. Yds.	ft.	in.	Depth from Surface. Yds.	ft.	in.
Blue Metal, with bastard iron bands..	2	1	1	....			191	1	1
Dark Shaley Metal	1	0	0	....			192	1	1
Dark Shaley Metal, with iron bands..	1	2	0	....			194	0	1
Hard Rock Bands, bastard and coarse	0	1	0	....			194	1	1
Rock Bands	1	1	0	....			195	2	1
Good Red Metal	1	2	0	....			197	1	1
Metal Mixed with Warrant....	1	1	6	....			198	2	7
Black Bands, coaly	0	2	10	....			199	2	5
Blue and Red Metal	4	2	0	....			204	1	5
Blue Metal, stained with red ..	4	1	0	....			208	2	5
Blue and Red Metal, with iron bands and hematite floors....	3	1	6	....			212	0	11
Coal .. .. .. 8 in. Band or Warrant 11 in. Coal .. .. .. 7 in. ..	0	2	2	....			213	0	1
Red and Blue Metal, mixed....	1	1	1	....			214	1	2
Soft Metal..	6	0	4	....			220	1	6
COAL	1	0	4	7	1	7	220	2	10
Very Soft Metal	3	2	7	....			224	2	5
Strong Blue or Grey Metal, with sulphur balls	1	2	9	....			226	2	2
Blue Metal	1	2	1	....			228	1	3
Coal .. 0ft. 10in. Warrant 1ft. 0in. Coal .. 0ft. 7in.	0	2	5	....			229	0	8
Blue Metal	6	2	7	....			236	0	3
Coal	0	1	0	6	2	7	236	1	3
Blue Metal	1	0	9	....			237	2	0
Coal .. 0ft. 3in. Warrant 1ft. 0in. Coal .. 0ft. 5in.	0	1	8	1	0	9	238	0	8

Description of Strata.	Thickness of Strata. Yds.	ft.	in.	Distance between Mines. Yds.	ft.	in.	Depth from Surface. Yds.	ft.	in.
Warrant and Bad Ground ..	2	0	7		....		240	1	3
Coal	0	1	1	2	0	7	240	2	4
Fairly Good Blue Metal	4	1	1		....		244	3	5
COAL	1	0	1	4	1	1	245	3	6
Warrant	0	2	8		....		247	0	2
Grey Metal inclined to Red with iron bands and bastard rock	1	2	11		....		249	0	1
Grey Metal and Rock	3	1	6		....		252	1	7
White Rock, with metal floors inclined to red	3	0	0		....		255	1	7
Grey Rock, with soft red floors	5	2	6		....		261	1	1
Coal	0	0	2		....		261	1	3
Soft Warrant	1	1	6		....		262	2	9
Stronger Warrant	1	0	6		....		264	0	3
Good Blue Metal..	1	0	9		....		265	1	0
Blue Metal, with ironstone bands and nodules..	4	0	3		....		269	1	3
INCE YARD { Coal .. 0ft. 2in.; Ironstone 0ft. 3in.; Coal .. 0ft. 6in.; Band .. 0ft. 1in.; Coal .. 2ft. 5½in. }	1	0	5½	23	0	9	270	1	8½
Warrant	0	1	6		....		271	0	2½
Coal and Dirt and Black Bass..	0	1	0		....		271	1	2½
Black Bands and Grey Metal ..	4	0	1½		....		275	1	4
Hoo Cannel Coal	0	1	10		....		276	0	2
Coal..	0	0	9		....		276	0	11
Warrant	0	2	0		....		276	2	11
Black Bass and Dirt..	0	0	9		....		277	0	8
Coal	0	0	6		....		277	1	2
Black Bass and Dirt..	0	0	6		....		277	1	8
Coal	0	0	9		....		277	2	5
Bastard Rock and Rocky Warrant..	0	2	0		....		278	1	5

Description of Strata.	Thickness of Strata. Yds.	ft.	in.	Distance between Mines. Yds.	ft.	in.	Depth from Surface. Yds.	ft.	in.
Strong Grey Rock and Burr Stone mixed up	2	2	0	....			281	0	5
Flaggy Rock..	1	1	7	....			282	2	0
Grey Metal, with rock bands or linsey	2	0	8	....			284	2	8
Grey Metal, with rock bands and ironstone bands	6	0	0	....			290	2	8
Very Dark Metal, with thin iron bands	4	0	8	....			295	0	4
Very Dark Soft Metal..	1	0	0	....			296	0	4
Black Stone	0	1	9	....			296	2	1
Ironstone Band	0	0	3	....			296	2	4
Coal .. .. .. 1ft. 3in. Dirt .. ..1ft. 0in. Bass and Dirt .. 1ft. 0in.	1	0	3	....			297	2	7
INCE FOUR FEET COAL..	1	1	9	27	0	10½	299	1	4
Strong Warrant	3	0	10	....			302	2	2
COAL	0	2	6	....			303	1	8
Blue Metal, soft and jointy....	3	0	0	....			306	1	8
Black Bass and Blue Metal ..	1	1	1	....			307	2	9
Black Stone and Blue Metal ..	1	2	0	....			309	1	9
Very like Hoo Cannel..	0	2	0	....			310	0	9
Black Bass and very soft Ground Metal	3	2	6	....			314	0	3
Bass and Soft Metal	0	2	8	....			314	2	11
INCE 7 FT. { Coal .. 1ft. 1in. Black Dirt, 0ft. 4in. Coal .. 1ft. 0in. Band.. ..0ft. 1in. Coal .. 1ft. 9in. }	1	1	3	15	1	7	316	1	2
Very Strong Warrant	2	0	0	....			318	1	2
Flaggy Rock..	0	1	0	....			318	2	2
Black Bass Soft	0	0	6	....			318	2	8
Very Strong Linsey	4	2	6	....			323	2	2

Description of Strata.	Thickness of Strata. Yds.	ft.	in.	Distance between Mines. Yds.	ft.	in.	Depth from Surface. Yds.	ft.	in.
Very Strong Linsey, with iron bands	2	2	0	....			326	1	2
Strong Grey Rock, with burr bands and balls of burr	4	2	0	....			331	0	2
Black Bass	0	1	3	....			331	1	5
Black Stone, like Hoo Cannel..	0	2	0	....			332	0	5
Grey Rock, with strong iron bands..	2	1	0	....			334	1	5
Blue Metal	1	1	0	....			335	2	5
Do., with hard iron bands	1	1	0	....			337	0	5
Black Bass	1	0	0	....			338	0	5
Coal..2ft. 2in. Dirt..0ft. 5in. Coal..0ft. 7in. Dirt..0ft. 4in. Coal..2ft. 4in. } DIRT or FURNACE MINE.	1	2	10	21	2	3	340	0	3
Warrant	3	2	0	....			343	2	3
Grey Metal	2	0	0	....			345	2	3
Black Bass	0	1	0	....			346	0	3
Do., Warrant and Dirt..	0	1	11	....			346	2	2
Black Bass, with coal partings and dirt	0	2	4	....			347	1	6
Coal	0	1	0	....			347	2	6
Warrant and Grey Rock	1	1	0	....			349	0	6
Hard Grey Rock, with strong bands	4	2	3	....			353	2	9
Blue Metal, with iron bands ..	1	0	6	....			355	0	3
Do., with faulty ground	1	0	0	....			356	0	3
Soft Faulty Ground..	2	2	0	....			358	2	3
Blue Metal, with iron bands ..	1	2	6	....			360	1	9
Coal	0	1	1	....			360	2	10
Blue Metal and Faulty Ground.	1	1	11	....			362	1	9
Very Faulty ground	1	2	0	....			364	0	9
Soft Metal, with iron bands ..	1	0	10	....			365	1	7

Description of Strata.	Thickness of Strata. Yds.	ft.	in.	Distance between Mines. Yds.	ft.	in.	Depth from Surface. Yds.	ft.	in.
Warrant, Metal and Iron Nodules	2	0	2		....		367	1	9
Strong Grey Metal	6	1	0		....		373	2	9
Strong Grey, with hard rock bands, or flaggy, or Lime and and Wool	6	2	8		....		380	2	5
Strong Grey Rock	7	2	1		....		388	1	6
Hard Grey Rock, with burr ..	14	1	0		....		402	2	6
COAL (PEMBERTON FIVE FEET)	1	0	0	62	2	3	403	2	6
Warrant	1	0	0		....		404	2	6
Black Bass	0	2	0		....		405	1	6
Strong Rock Bands	1	0	4		....		406	1	10
Blue Metal and Iron Bands....	7	0	0		....		413	1	10
Hard White Rock	0	2	0		....		414	0	10
Faulty Ground and Metal	2	2	0		....		416	2	10
COAL (PEMBERTON TWO FEET and FOUR FEET)..	2	0	3	13	0	4	419	0	1
Warrant	0	2	6		....		419	2	7
Hard Rock	5	1	6		....		425	1	1
Coal	0	0	11		....		425	2	0
Warrant	0	2	0		....		426	1	0
Strong Metal, with iron bands.	1	1	5		....		427	2	5
Do. or Linsey	2	1	0		....		430	0	5
Hard White Rock	2	0	4		....		432	0	9
Strong Metal	0	1	8		....		432	2	5
Coal	0	0	4		....		432	2	9
Warrant	1	1	8		....		434	1	5
Blue Metal	1	0	0		....		435	1	5
Blue Metal, full of hard burr bullions	14	0	4		....		449	1	9
Hard Blue Metal, inclined to rock	9	1	0		....		458	2	9
Hard Blue Metal and rock bullions	8	2	5		....		467	2	2

Description of Strata.	Thickness of Strata. Yds.	ft.	in.	Distance between Mines. Yds.	ft.	in.	Depth from Surface. Yds.	ft.	in.
Hard Blue Metal full of iron bullions	10	0	3	....			477	2	5
Coal, 8 in. .. .. .. Dirt, 1 in. .. .. Coal, 9 in.	0	1	6	....			478	0	11
Warrant	0	2	3	....			479	0	2
Hard White Rock	4	1	0	....			483	1	2
Strong Metal, inclined to rock.	10	0	0	....			493	1	2
Dark Metal	3	0	6	....			496	1	8
Blue Metal and Iron Bands ..	8	0	0	....			504	1	8
Dark Metal do. do.	4	0	3	....			508	1	11
Coal	0	1	3	....			509	0	2
Blue Metal with Iron bands ..	2	2	2	....			511	2	4
Coal	0	0	11	....			512	0	3
Warrant	0	0	7	....			512	0	10
Coal	0	1	0	....			512	1	10
Warrant and Metal	1	0	6	....			513	2	4
Dark Metal	2	2	0	....			516	1	4
Coal	0	0	5	....			516	1	9
Dark Metal	0	0	4	....			516	2	1
Coal	0	0	7	....			516	2	8
Dark Metal	5	0	0	....			521	2	8
Coal	0	0	8	....			522	0	4
Metal	0	0	6	....			522	0	10
Coal	0	0	10	....			522	1	8
Warrant	0	2	0	....			523	0	8
Dark Metal and Iron Bands ..	6	1	2	....			529	1	10
Coal	0	1	0	....			529	2	10
Sparry Rock and rock, inclined to burr stone	2	2	10	....			533	0	8
Metal and strong iron band....	0	2	10	....			534	0	6
Flaggy Rock	1	2	8	....			536	0	2
Dark Metal	3	1	6	....			539	1	8

Description of Strata.	Thickness of Strata. Yds.	ft.	in.	Distance between Mines. Yds.	ft.	in.	Depth from Surface. Yds.	ft.	in.
Coal 1 ft. 6 in., Dirt ½ in., Coal 5½ in., Warrant 6 in., Coal 4 in.	0	2	10	....			540	1	6
Warrant	1	0	3	....			541	1	9
COAL (WIGAN FIVE FEET)	1	1	3	122	1	8	543	0	0
Warrant	2	0	0	....			545	0	0
Strong White Rock and Flaggy Rock	2	1	2	....			547	1	2
Blue Metal	7	0	5	....			554	1	7
Coal	0	0	10	....			554	2	5
Strong Linsey, inclined to rock..	1	1	9	....			556	1	2
Grey Rock	3	0	10	....			559	2	0
COAL (WIGAN FOUR FEET)	0	1	7	17	0	10	562	0	10
CANNEL (WIGAN FOUR FEET)	2	0	3						
Warrant	2	0	0	....			564	0	10
Coal	0	1	8	....			564	2	6
Warrant	0	2	5	....			565	1	11
Blue Metal	2	1	10	....			568	0	9
Warrant	0	2	3	....			569	0	0
Strong Blue Metal and iron nodules	2	0	2	....			571	0	2
Strong Metal and iron bands ..	4	2	0	....			575	2	2
Black Shale and iron bands ..	2	1	0	....			578	0	2
Very Dark Shale	1	1	6	....			579	1	8
COAL (WIGAN SIX FEET)..	1	2	6	....			581	1	2
Warrant	0	2	9	....			582	0	11
Soft Shale..	0	0	9	....			582	1	8
Blue Metal	2	1	6	....			585	0	2
Do., and iron bands ..	6	1	0	....			591	1	2
Metal and Iron bands	1	2	0	....			533	0	2
Strong Metal, with iron bands and nodules	4	0	0	....			597	0	2
Faulty Ground	1	0	10	....			598	1	0
Coal	0	0	9	....			598	1	9
Faulty Ground, fairly good ..	5	1	2	....			603	2	11

The Chairman (Mr. W. S. Barrett): I am quite sure that we have all listened with very great interest to the exhaustive paper which Mr. Keen has put before us. It seems to give the romance of coal mining. Mr. Keen has gone on with the work when most men would have thought that the life of the colliery was exhausted; and whatever difficulties have arisen, he has dealt with them in the able manner which he has described. We are always told that money and engineering can overcome anything, but I do not think these could have been of avail if there had not been at the back of them the pluck and the work which distinguished the operations we have had described. There must have been times at this colliery when Mr. Keen would have been very nearly hopeless, but on each occasion of apparent disaster he rose to it and overcame the difficulties. With regard to the engineering part of the paper, I am not qualified to give an opinion, but I cannot but admire the spirit of the work which has been done, and I think Mr. Keen's concluding remarks show that he has not only had the interest of the Moss Hall Coal Company at heart, but has kept the saving of human life and the prevention of accidents constantly before him. Either interest is a terrible responsibility, but when both are combined it requires great determination to carry on, and the result must be a great satisfaction to Mr. Keen and to the Moss Hall Coal Company, as it is to us here this afternoon. Mr. Keen has also given us a good deal of advice, which you are quite able to appreciate, namely, to have the best of everything and to use it to the best advantage.

Mr. J. Dickinson: I beg to move that the thanks of the Society be given to Mr. Keen for the description which he has given us of the difficulties that he has so successfully encountered. I wish also to couple with the vote of thanks the name of Mr. Caldwell for the facilities which he and Mr. Keen have afforded to mining engineers generally during

the operations, to see how the difficulties were met with in detail. The description that Mr. Keen has given us leads me to say that I think most of us must have felt that we were sitting at the feet of a Gamaliel in colliery sinking, and we are glad to find that this winning has been brought to a successful termination, and that a bed of Cannel, which is, I understand, about six feet in thickness, has been met with, which seems in all likelihood to be the means by which the great expense that has been incurred will be re-imbursed, and the owners of the colliery remunerated for the winning. Among the details which Mr. Keen has enumerated, many of them are novel, but one which is specially emphasised is one which I saw in operation about 45 years ago in the sinking of the Astley Pit at Dukinfield, where they endeavoured, as Mr. Keen has endeavoured, not only to carry out the work with safety to human life but also with comfort to the workmen, so far as was possible under such disadvantageous circumstances, in keeping the water off their backs and coming down upon their heads. The operation I allude to was the hanging of wooden cases one by one until they got down to a good foundation for the bricking up. I do not think they carried them out with such detail as Mr. Keen has carried them out, as I understand from his description he actually made junctions of these wooden casings in sinking below, which were watertight.

Mr. KEEN: No they were not exactly watertight; but they were so fastened that no water fell upon the men.

Mr. DICKINSON: They were sufficiently tight to prevent anything falling from the sides on the sinkers?

Mr. KEEN: Oh, decidedly.

Mr. J. RIDYARD: I have great pleasure in seconding the motion. I think this is an occasion on which we should all congratulate both the Moss Hall Coal Company and Mr. Keen on the success which has attended their labours. We must all see that the time is not far distant when similar sinkings will have to be undertaken, because the coal seams near the surface are pretty well exhausted in South Lancashire, and this being a pioneer attempt to sink through the Red Sandstone, it is an event on which the Company and Mr. Keen deserve our congratulations. I am sure it must be gratifying to the Moss Hall Coal Company, to Mr. Keen, and to South Lancashire generally, that success has attended these efforts.

The CHAIRMAN; I am sure we all congratulate them on the sinkings, and wish that the coal and cannel they have discovered will be an ample reward for their arduous labours.

Mr. KEEN: I am much obliged to you for the very cordial vote of thanks you have given me. I have, as far as I have been able, endeavoured to show everyone, who has wished, our works at Maypole, particularly people connected with mining. We have had your members over once, and I hope we may have them again, when they will see the cannel workings in operation. We have had the mining students upon many occasions, and it has always been most gratifying to me to see them at Maypole. I hold that the only good you do in this world is the benefit that you give to succeeding generations, and so far as any knowledge that I have, or any information that I have got during the sinking of these pits, I shall be very glad at any time to use it for the benefit of my fellow members of the mining profession. I am very much obliged to you, gentlemen, for the vote of thanks.

Mr. H. HALL: Might I suggest that the discussion on Mr. Keen's paper be adjourned. Although Mr. Keen has given us so much information, I think with a little more "sinking" into the subject we may find some more, and if we adjourn it to some future meeting, we shall have the pleasure of seeing Mr. Keen again. I move that the discussion be adjourned to some future day.

Mr. J. TONGE seconded the proposition.

The CHAIRMAN said it would be wise to adjourn, as no doubt an interesting discussion would arise.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XXVI. SESSION 1898-99.

The ORDINARY MEETING of the Members was held on Tuesday, February 14th, 1899, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. JOHN GERRARD, in the Chair.

STRIATED BOULDER FROM BLACKPOOL.

Mr. JOSEPH DICKINSON exhibited a striated boulder from the clay at Blackpool, and said: I have brought a very good sample of these striated boulders, which I took out of the clay cliff facing the sea, near the Gynn, when I was at Blackpool last year. The stone is a hard blue rock, and the groovings are very distinct; they are of various depths, and some of them are straight, whilst others are slightly curved; and the lines cross each other in various directions. The striated boulders there are largely of Silurian age.

A SEPTARIAN NODULE.

Mr. STIRRUP exhibited and described a small Septarian nodule, from the Lias of Leicestershire, which disclosed an exceptionally fine interior. He said: Nodules of this

character are obtained from many formations. The large specimens exhibited in this room two or three months ago, were from the Carboniferous rocks; this is from the Lias clay. Such nodules are very frequent in the Jurassic rocks, and in the clays of the Greensands; they are also found in the Eocene. At some places, Weymouth, for instance, they are polished and are called "turtle stones," from the supposed resemblance to the shell of the turtle. One must suppose that this nodule has dried in course of time, and that it has cracked, as clay will, and the lime has either segregated from the clay, or it has infiltrated into the cracks, and filled them up with calcite in the beautiful way which we see in this little hand specimen.

I brought it in order to show that these nodules are not from one geological formation only. Wherever there is a marly clay they may be found, with the cracks filled with crystallised carbonate of lime.

Mr. BARNES: It is not always carbonate of lime, but a mixture of carbonates of lime, iron, and magnesia.

THE INTERNATIONAL CONGRESS OF GEOLOGISTS, 1900.

Mr. STIRRUP brought before the members the preliminary circular giving particulars of the International Geological Congress which is to be held in Paris during the exhibition year, 1900. Excursions have been arranged to different parts of France, including Auvergne, the Commentry coal-fields, the Rhone, Pyrenees, etc.

SINKING THROUGH HEAVILY WATERED STRATA AT ABRAM.

The CHAIRMAN said they would all much regret the absence of Mr. Keen, whose paper, read at Wigan—"On Sinking through heavily Watered Strata at Maypole Colliery, Abram, near Wigan,"—they were to discuss. Any member who might have come prepared to make observations or ask questions in regard to Mr. Keen's paper could now do so.

Mr. JAMES TONGE said: I should like to say how pleased I was to hear an opinion, which I have held for a long time, confirmed, but which was disputed at a meeting here a few years ago. I refer to the "backing" in the bricking of shafts, that is, what you may put behind the brickwork. I remember I read a paper on sinking a pit at night, and winding coal in the day, and I mentioned that I took particular care not to leave any spaces behind the brickwork, and not to have any loose cinders or ashes. I was pleased to hear Mr. Keen speak so strongly on that point, and to recommend, as I have felt for years should be done, that everything should be solid—either bricks or mortar or cement—all round the shaft behind the brickwork. I have been in shafts on several occasions when bricks and ashes have been falling from behind the brickwork. This was clearly traceable to the practice of filling the space behind the bricks with ashes and other loose material, a practice which no one who has been in the position named would ever recommend. Whether any of our members are still in favour of loose backing I do not know, but I am as strongly convinced as I was when I read my paper that on no account should loose material be used for filling between the brick-

work and the shaft side. I remember seeing in a certain shaft, 20 yards of brickwork come out all at once. This was chiefly due to the loose backing.

Mr. DICKINSON: Mr. Tonge has mentioned one of the numerous useful points in the paper. What he advocates is not a novel thing. It has been the practice I think, for many years, in this district, to fill up solid behind the brickwork in pit shafts, and indeed, where cinders have been used, to grout them with cement or with Ardwick lime. Some of the finest shafts have been set with Ardwick lime, which has only one drawback, namely, that it is rather slow in setting. At present I do not think the Ardwick limestones are being worked, as the proprietors have large stocks on hand to supply the demand. One part Mr. Keen mentioned to me (I do not think it appears in his paper) was that as soon as they got their shaft down to the cannel coal, which is 6 ft. 3 in. thick, the cannel gradually heated till it became exceedingly warm. I should like to hear if any member has any theory to offer in explanation of this Most of us who are conversant with copper mines know that a chemical action takes place, and the water and air become heated, but for the cannel coal to heat, as Mr. Keen described, is something novel. Another point which I have many times observed is that when coal mines have been sunk to a certain depth, the temperature is much higher than, say, in an ironstone mine of the same depth.

Mr. STIRRUP: I suppose the loose backing which Mr. Tonge has described will allow of the accumulation of water behind the brickwork, and this, I suppose, will force the bricks out. There will not be anything specially in the cinders, I take it, to cause displacement of the brickwork?

Mr. TONGE: If there should be a crushing at any particular point, when the space behind the brickwork

is filled with mortar or cement, and all made solid, the side of the shaft is not affected, for it is lined as with an iron band. A loose backing, on the contrary, offers scarcely any resistance, and a stone wedging can push the brickwork out; then, when holes are made in the side, the loose material is let out and falls down the pit shaft. Mr. Dickinson remarked that the system I recommend is not modern—that it has been followed for some time. That is so; but I was rather taken aback, at the time I mentioned, upon hearing some members of this Society contend (and if I remember rightly, a paper was read, following mine) that loose backing was better than solid.

The CHAIRMAN: I hope it was in the youthful days of the Society, for I think we are most of us of opinion, with Mr. Dickinson, that if not obsolete it ought to be. The difference between a solid backing and ashes has been over and over again proved. With reference to the very interesting observation of Mr. Dickinson, as to temperature, I am sure that might be submitted to our next meeting, when we hope to have the pleasure of Mr. Keen's presence. The splendid work Mr. Keen has done has excited the admiration of the whole mining world, and the generous way in which he has enabled any and all to see his work—and the equally generous way in which he has contributed information to the members of this Society—must meet with the approval of all engaged in mining.

Mr. BURROWS having temporarily taken the Chair.

Mr. GERRARD described a recent outburst of gas at Westleigh Colliery.

AN OUTBURST OF GAS AT WESTLEIGH COLLIERY.

By Mr. John Gerrard.

There is nothing new in the fact of an outburst of gas. Such occurrences have, from time to time, been brought before meetings of mining engineers, and it is the belief that they should be recorded which has led me to prepare this short communication for the Society. It is of importance to preserve these records; they help to strengthen the hands of those in charge of mines—managers and mining engineers—and show the advantage and importance of the safe lighting of mines, the use of safe explosives, and the maintenance of strict discipline; for, as these outbursts have occurred in mines where they were little expected, so they may occur again in other mines. Many of the outbursts which have been recorded may be said to be ordinary ones, arising from accumulations of fire-damp in cavities formed by the ordinary working of the mines, and generally in the floor. The outburst at the Westleigh Colliery in December last, however, may be described as extraordinary. It occurred in the Wigan 4ft. mine, on the 16th December, 1898, about 2-30 p.m. James Armstrong, collier, left his working place, having finished work, the place being a level, eight feet wide, the face all squared off. When travelling outbye with others, at about 320 yards from his place he heard a report, and felt the air current they were travelling against, checked; they spoke of it as being like a blown-out shot somewhere, or a large fall of roof. They went out without making any report to the officials. The shock was felt by a boy 1000 yards outbye. No official had cause to go near the place until about 2-40 a.m. the next

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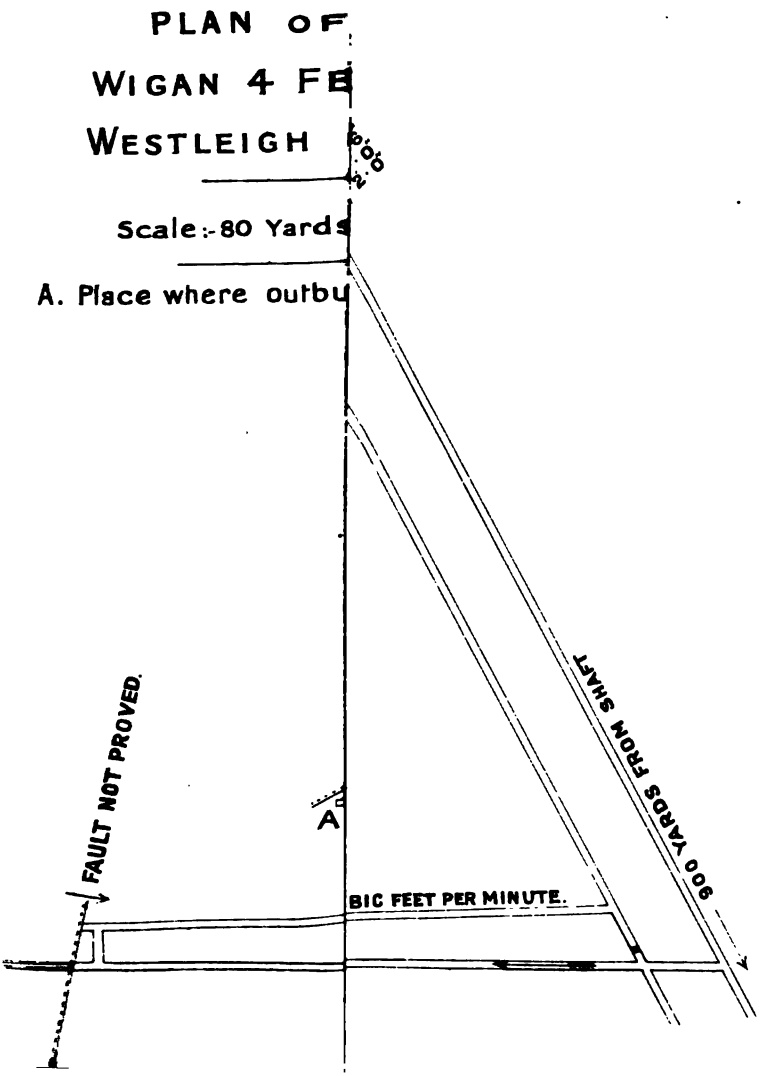
To illustrate Mr. Gerrard's Paper on
an outburst of Gas at Westleigh Colliery.



day, when the fireman, Bernard Heaton, approached the place on his round of examination, prior to the entry of the colliers. Heaton found the brattice cloth down 30 yards from the face, the rails all disturbed, being in a zig-zag position; pieces of stone and coal lay on the floor. As he got nearer to the face, the debris got thicker, and the pieces of stone and coal larger, until he was stopped some yards from the face, the place being full of fire-damp. Subsequently, on the ventilation being restored, examinations showed that some tons of coal and rock had been blown from the solid at the right hand corner of the level. Three days afterwards, fire-damp was found very strong in the cavity. The place was allowed to stand until an opening was driven through from the level below. When this was completed, on the 11th of February, it was possible to remove the pieces of stone, and on the 13th of February, the place was explored. It was found that solid coal had been expelled from the higher side of Armstrong's working place, for a distance of seven feet, forming a space five feet in width. At the back of the space was a fault, a down throw of three feet. In the roof was a cavity extending upwards from the floor 29 feet, the top not being reached. Firedamp was very strong in the cavity. As before stated, pieces of rock were found 30 yards from the face, some of the pieces being several pounds in weight. Nearer to the face the debris lay in a thick continuous layer. One piece of coal, five yards from the face, was about the thickness of of the seam, 3 ft. 6 ins. deep., 2 ft. 4 ins. wide, and from front to back, 15 ins. Another piece of coal, six yards from the face, was 26 ins. × 26 ins. × 14 ins. Several of the pieces of rock would probably weigh three or four cwts. Two yards from the face was a piece of rock 3ft. 10ins. × 2ft. × 1ft. 4ins. Near by, another piece, 2ft. 2ins. × 1ft. 5in × 1ft. 4ins. Water was given off, about 20 tubs, or about 2,000 gallons of water

collected, and probably half that quantity may have soaked into the floor. The sides of the place, and all the props on the face side, had the appearance of being whitewashed, being coated with a white sandy deposit.

When Armstrong, the collier, ceased work, the coal face was squared up, no holing. A little water was trickling from the higher side corner, making about a tub, or 109 gallons, in eight hours. This water had been made for several days, gradually increasing in quantity. At about sixty yards from Armstrong's place on the one side, the downthrow fault was proved in a brow on 1st July last, firedamp being given off; on the 4th of August the fault was bared in the back brow. Jonathan Simpkin, the collier, states that a spurt of water struck him on the chest, and firedamp put out his light. About 120 yards on the other side, the lower side, a large upthrow fault has been bared but not proved. There are about 200 yards of solid coal on the outbye side of the fault in Armstrong's place, the fault being that distance from the boundary of the royalty. The Heyfield drawing pit and downcast shaft is 410 yards deep, Armstrong's place is about 750 yards on the dip of the shaft, and along the level, so that at that point there may be about 535 yards of cover to the surface. The seam dips about 1 in 6. Neither the seam above (the Wigan four feet), nor the seam below (the Wigan six feet) has any goaf near to Armstrong's place. Whilst no evidence was obtained of the volume of firedamp given off, it is obvious from the pressure exerted there must have been a considerable amount. It is certain that James Armstrong had a marvellous escape, for had the outburst occurred a few minutes earlier, when Armstrong was at the face, he would in all probability have lost his life.

After examination of the coal and stone found in the level, it appears probable some twelve tons had been

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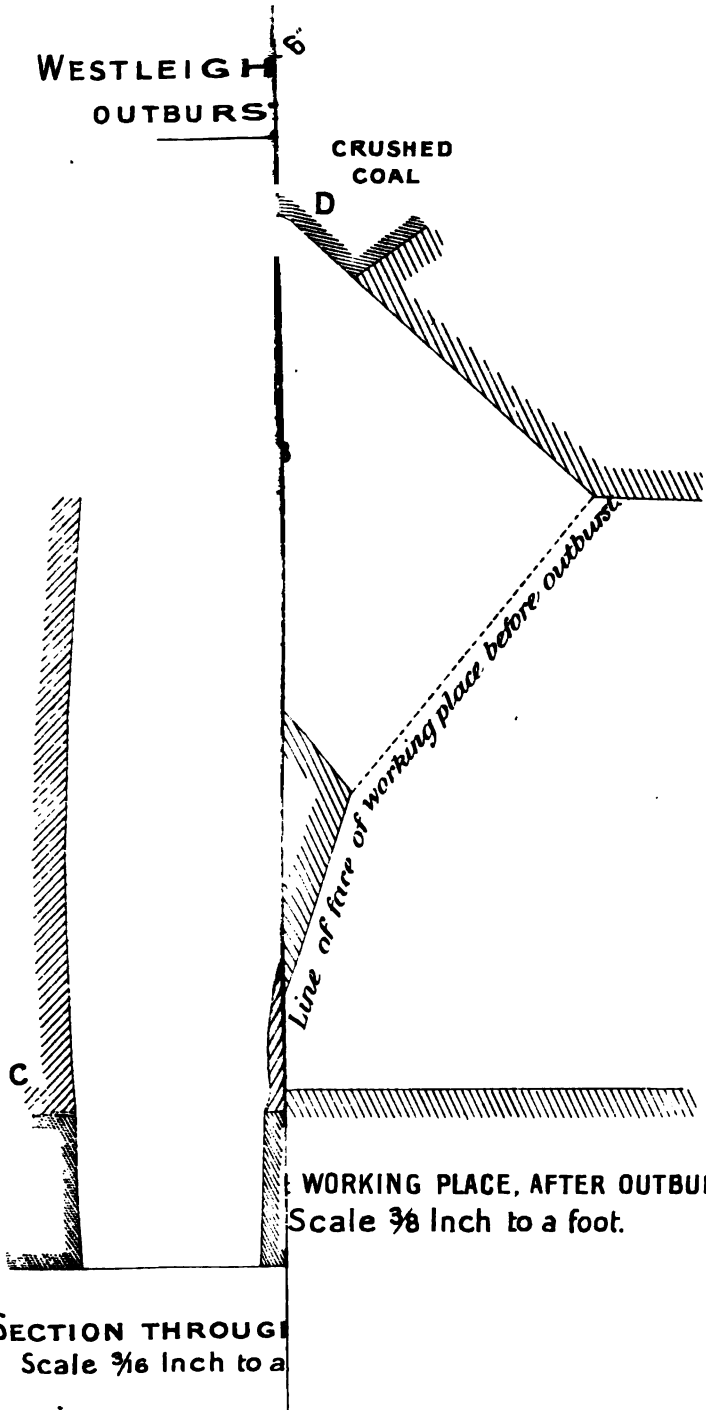


expelled. This would be solid material, and points to enormous force having been exerted. It would also appear that a space of certainly 500 cubic feet exists, showing that there may have been a cavity approaching in content 300 cubic feet.

The following is taken from the section found in sinking the Heyfield shaft:—

		Yards.	Feet.	Inches.
	Metal	6	0	0
	Coal	0	0	3
	Bass, etc.	1	2	0
	Coal	0	0	3
	Warrant	1	0	6
	Rock	7	1	6
Wigan four feet seam.	Coal	0	1	4
	Band Dirt	0	0	1
	Coal	0	2	5

The Chairman (Mr. Burrows) said: I am sure we are very much obliged to Mr. Gerrard for his very interesting paper. I can quite echo what he said about good safety lamps and discipline. I think it was at the Oaks Colliery that an explosion was caused by an outburst of gas from the floor. My own practice—and I recommend it to anyone who has not done it—is, to look at the section of the strata sunk through, in commencing a new mine, and spend a little money in boring both up and down. We have done it sometimes with no result whatever; in other cases we have found a large amount of gas; but I think it is a simple and necessary protection, and will pay for itself. It is very pleasing, in one sense, that the cause of this has been bottomed, because, in some other outbursts the source of the gas has not been found.

We have been driving a level tunnel lately, I may say, *apropos* of these sudden outbursts, in exceedingly hard rock; it broke our drills, sometimes two or three times in a shift. The roof and face had to be spragged because the rock kept flying off without warning, yet it was so hard we could with difficulty temper our drills to face it. No gas was ever seen in the tunnel, yet pieces of rock were forced off six or nine inches thick, and a yard square; and that bears out an idea I have long had, that in many of these cases it has been due to some peculiar condition of compression in cooling, just as in a cast-iron fly wheel, sometimes the rim will fly without any apparent reason. In my opinion this rock must be strained in a similar manner, and, having no elasticity, it breaks away. Some of the men had narrow escapes of being seriously hurt before the danger was realised. In most cases there were not more than 24 yards of superincumbent strata to a coal place above, so that I think it could not have been the weight above that caused the fractures; pieces fell from the roof and sides even in the hardest rock. If gentlemen, who have the same chances as Mr. Gerrard of noting these outbursts, would kindly give us their information, as practical men, it would be put to good use; and I am sure Mr. Gerrard will be glad to hear any criticisms that may be offered on his paper. Mr. Gerrard pointed out in the section, an area where the coal had been all crushed.

Mr. ATHERTON said: I have not had experience of such an outburst, but the description Mr. Gerrard has given has been most interesting to me. I have occasionally come upon coal in a mine, which has been soft, as if crushed, but from no apparent cause. This has occured forty or fifty yards from any fault. I never could account for it, because everywhere else the coal was perfectly solid. Probably others may have had experience of the same thing.

Mr. DICKINSON: It is very satisfactory that Mr. Gerrard has brought such a case before the Society. It is now some years since a similar outburst was recorded, though I have no doubt some have occurred in the interval; and if they may not have resulted in serious accidents it is due to the improved state of safety lamps at the present time. On that point we owe a deep debt of gratitude to M. Marsaut for the lamp which bears his name. When the explosion took place at the Altham Colliery, the current was too strong for the Davy lamp to resist, and the flame passed through the gauze. Nearly all the men had escaped before this happened, and were running out with their lamps full of fire. We had no practicable lamp at that time as a substitute for the Davy. The Marsaut had just come out, and it had not been tested. The Woolwich authorities had taken the only testing machine we had away from Wigan—one that Mr. Smethurst introduced—and they kept the experiments at Woolwich secret, and, though they had tested the Marsaut lamp, they would not give us any information till their report came out. I took the Marsaut to South Wales, to the Celynen Colliery, where safety lamps were tested, before being used, on every shift. The Marsaut stood the test except that when placed in a mixture of gas a little blue flame remained up in the top of the lamp, in the gauze. By contracting the supply of air to the lamp we were enabled to prevent that little blue flame from remaining there. But it interfered with the light given by the lamp, and although the flame was there it was found to be practically harmless. That lamp was introduced at the Altham Colliery, and it is used there still. Now there are thousands of Marsaut lamps in use in this country. Some little improvements have been introduced, and the name is being changed, but it must be admitted that we owe a great debt of gratitude to M. Marsaut. I have thought that he ought to be proposed for election as an honorary member of

this Society. He introduced the lamp and got neither fee nor reward for it. It is true he took out a patent, but that patent had in one respect been anticipated by Mr. Smethurst, and the patent was therefore declared invalid. The fact Mr. Burrows mentioned of solid rock giving way is rather unusual, for we generally find, except in some cavity, that the rock stands. We do know that at great depths the pressure of the fire-damp is that of many atmospheres, and that alone perhaps might be sufficient without any other cause. It is something new, and one can hardly offer any opinion upon it. Mr. Gerrard, referring to the chasm caused by the outburst at Abram, said that he used a pole but failed to reach the top. I remember, early in the fifties, a similar outburst occurred, accompanied by an explosion, at the Dyffryn Collieries. We got the longest pole we could find in the mine, but could not reach the top there. The practice of boring, which Mr. Burrows mentioned, is an old one in this country. When I came here they were doing it in the St. Helens Colliery; they were boring in the roof to prevent gas from forcing the timber down; and I think we have had before noticed in this Society the great quantity of gas that was made in the Trencherbone Mine. The Wigan Coal and Iron Company put bore holes down twenty yards because the gas was lifting their floors. The quantity of gas that came off was found so inconvenient that they put in stop cocks by which it was allowed to escape only when the men were out of the mine. It blew off like steam from a safety valve. But after a few weeks, or months, the gas was all drained off, and fresh holes were made as the workings advanced, and they, in that way, kept the Trencherbone seam clear of gas, and I think got through without any accident whatever. It was a source of great interest at the time.

Mr. Mathews: Have any of the seams been worked beyond the fault, draining any gas? Or is that the first seam worked across the listing of the fault?

Mr. GERRARD: The Westleigh Colliery is immediately to the east of our boundary. On the west side you have the Abram Colliery, where I fancy the Company work the Wigan four feet for that excellent seam of cannel coal. But what I was anxious to know was the distance between the scene of this outburst and where workings might possibly be; and I am absolutely certain that there are 200 yards of solid coal up to the boundary of this royalty. What has been done on the other side of that boundary I do not know.

A MEMBER asked if the coal was not worked in any of the seams above the fault; or was it all solid?

Mr. GERRARD: It is practically solid. The seam above is the Wigan 5 ft., which is not extensively worked near there; but I am sure there is a solid area round the scene of this outburst in the Wigan 4 ft.

Mr. MATHEWS: In the Wigan district, a short time back, a firm had bored a hole through a break in the roof. The fireman could not put his safety lamp to examine higher up the cavity than the height of the bore-hole, and he thought it would be safe to fire a shot, but he afterwards found that there was a little gas, which exploded, above the line of the bore-hole. It shows how necessary it is to be careful where there is a break in the roof when shot-firing.

Mr. BURROWS said: I am afraid Mr. Dickinson did not quite understand me about the gas, and the splitting off of portions of hard rock. I should have thought it was gas myself, only this is a level tunnel working under the engine-brow, and exactly under the place worked some months before. If it had been a new tunnel, or virgin ground, we should almost have been forced to the conclusion that it was gas, but of this we found not a trace. If all the outbursts had been recorded which have occured during the last 20 or

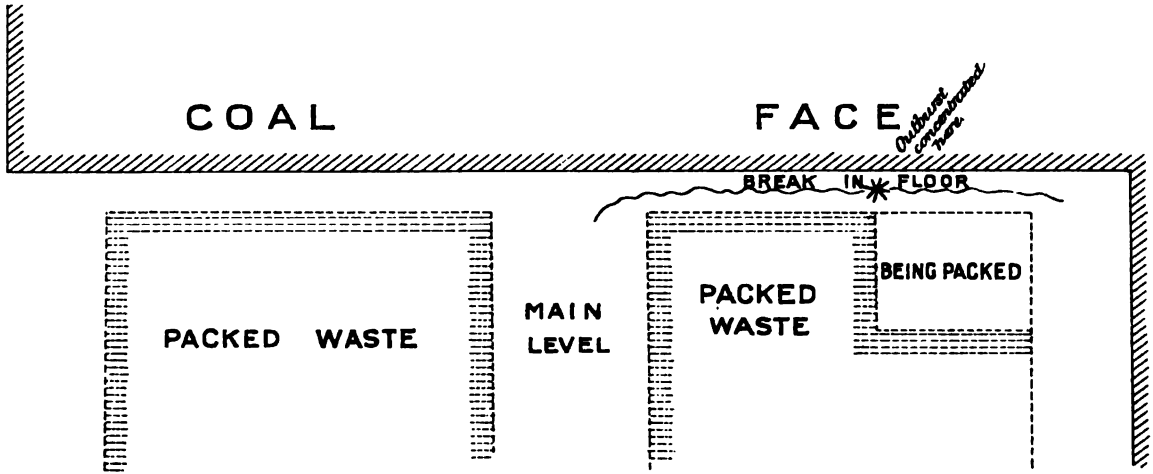
30 years, people would shudder to think what imminent risk there had been of explosions. I think it was Mr. Dickinson who first brought the Marsaut Lamp to these meetings. As soon as we saw it, we fitted our colliery with it from top to bottom, and displaced the Mueslers, which had served us well for some time. I have pleasure in moving that our best thanks be given to Mr. Gerrard for his paper.

Mr. DICKINSON: I have much pleasure in seconding that motion, and I hope it is not by any means the last paper he will favour us with.

The vote of thanks was passed unanimously. Mr. Gerrard briefly responded, and the business of the meeting concluded.

Mr. GERRARD has since supplied the following notes on an outburst of fire-damp at Blainscough Colliery.

Trans. Man. Geo. Soc. Part V. Vol. XXVI.
To illustrate Mr. Gerrard's Note on
an outburst of Gas at Blainscough Colliery.



PLAN OF WORKING PLACE IN THE ARLEY MINE,
BLAINSCOUGH COLLIERY, COPPULL.

Scale 5 Yards to the Inch.

NOTE ON AN OUTBURST OF FIRE-DAMP AT BLAINSCOUGH COLLIERY.

By Mr. John Gerrard.

On the 6th of November, 1897, about 1-30 a.m., in the Arley Mine, Welch Whittle, in the main level, 530 yards from the shaft, in a wide workplace, whilst three men were engaged packing the waste, the roof began to weighten, props cracked and the floor heaved alongside the face. There was a loud hissing noise, like unto the blowing-off of steam. This lasted about three minutes; all their lights were put out and there was a strong smell. When the roof had quietened, the men crept out of the place, and the leader went to see after twelve other men, employed on their return side. These men were met making their way out, all their lights having been extinguished. The fireman being sent for, an examination of the return was made. Near to the upcast shaft, the return was found to be charged with firedamp. After placing a man in charge of the doors leading to the return, to prevent anyone entering, the fireman went to examine the working place whence the gas came. The whole of the face above the level and on the return side was found to be charged with gas. The manager and under-manager were sent for. By the time they arrived, about 3 a.m., the gas had cleared away; careful examination proved the mine to be quite clear, and the places all safe. From a crack or break in the floor gas was issuing, but not more than could be diluted by the air passing through the place. About 11,000 cubic feet of air

per minute passed through the working place, and about 33,000 cubic feet passed along the return to the upcast shaft. The lamps in use were Meuseler, without shield. For a short time previous it had been noticed that the roof and floor had changed somewhat, the roof being stronger, the floor weaker. This was further shown by the floor heaving. After this warning, whilst the floor continued to heave, bore holes were systematically put down to relieve any gas and prevent an accumulation.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XXVI. SESSION 1898-99.

The ORDINARY MEETING of the Members was held on Tuesday, March 14th, 1899, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. CLEGG LIVESEY, J.P., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Members of the Society:—

Mr. OSWALD B. LEIGH, Stoneleigh, St. Anne's-on-Sea.

Mr. A. E. TANSLEY, Springfield House, Coppull, Chorley.

THE EARTHQUAKE OF FEBRUARY 27TH.

Mr. MARK STIRRUP called attention to the shock of earthquake which was felt over a limited area, near Manchester, on the evening of Monday, February 27th. He said: Some of us were astonished about a fortnight ago (on reading our morning paper) to learn that an earthquake had been felt in this district, and chiefly in the Pendleton area. From paragraphs in the newspapers, and from personal talk amongst our friends, it would appear that little is popularly known with regard to earthquakes—that is, as to their cause or probable origin. Some ten years ago, on February 10th, 1889, an earthquake shock occurred in the same neighbourhood, but of greater intensity, and extending to Bolton, Chorley, and beyond, which was very largely commented upon in the press. This recent one has been apparently much more local in extent. It was felt at Prestwich, as a friend informs me, but the newspaper paragraphs refer only to the neighbourhood of Pendleton, Seedley, and a little further out in that direction as far as Pendlebury. The popular idea is that earthquakes are in some way connected with volcanic eruptions, but as our district is a non-volcanic one, and these earthquakes are entirely local, for they cannot be shown to have had connection with any distant or Continental disturbance; that is to say, they cannot be the dying-out vibrations of some impulse which had its origin in some volcanic area. We must, therefore, try to find out some other cause to account for them.

There is a reasonable geological theory, which we may quite accept until something better appears to take its place, that all these earthquakes in non-volcanic areas have an intimate

relation to the geological structure of the district. It is well-known to all geologists that we have, in the neighbourhood of Pendleton, an extensive faulting of the strata which has been proved in working many of the coal mines of the neighbourhood; it is known as the great Irwell Valley fault. There has been a dislocation of the strata at some far back period of geological time.

We find that these earthquakes occur along the lines of that dislocation, as a rule. The late Mr. John Knowles, in a paper which I remember he read to us in the year 1889, on the earthquake of that year, stated the results of inquiries as to the extent to which the vibrations were felt underground, at considerable depths. The paper was read on March 12th, 1889, and it is somewhat of a coincidence that it should have been just ten years ago. A few days ago I wrote to Mr. Bramall, the general manager of Messrs. Knowles's collieries, who is a member of this Society, to ask whether any effects had been felt underground on the recent occasion in the mines under his control. He wrote me in reply as follows:—

Shade House, Pendlebury,
Near Manchester,
11th March, 1899.

Dear Mr. STIRRUP,

In reply to your enquiry about the earthquake, I am informed it was felt underground at Pendleton Colliery. Some falls of roof took place, and raised a cloud of dust which put the workmen's lamps out and created some alarm. The men were quickly re-assured, and having re-lighted their lamps, resumed work as usual.

The shock and noise were distinctly felt and heard in Whit Lane, Pendleton; near Agecroft Hall; at my house here; and at one of my official's residence near Swinton Station.

Yours faithfully,

HENRY BRAMALL.

MARK STIRRUP, Esq.

In the mine referred to they are working at the considerable depth of 1100 yards. These seismic phenomena, there is reason to believe, are primarily induced by some shrinkage or contraction in the strata, causing movement and friction, the attendant sounds and vibrations being undoubtedly propagated for some distance, and felt above ground as shakes. I sent all the information I could collect about the earthquake ten years ago to Mr. C. Davison, of Birmingham, whose pamphlet, subsequently published, on British Earthquakes of 1889 I hold in my hand. There is a paragraph or two in it, the substance of which I would like to quote as supporting the theory I have referred to as the probable cause of these local earthquakes.

Mr. Davison remarks that this interesting earthquake (1889) affected a district for the most part thickly populated, and the accounts of it are consequently numerous. Considering the smallness of the area, few previous earthquakes have afforded materials so abundant for the seismologist.

The seismic focus or source of the shock Mr. Davison traces to a place about two miles N.N.E. of Bolton.

He concludes from all the evidence collected at the time:—(1) That the Lancashire earthquake was caused by a slip of the Irwell fault, a few miles from its north-western extremity, as traced upon the map (in the pamphlet); (2) the horizontal length of the slip-area was short, possibly less than a mile; (3) the slip resulted in an increase of the throw of the fault; and (4) the slip must have extended upwards to within a short distance from, if not quite up to, the surface, the amount of the slip near the surface being of course extremely small."

Mr. Barnes reminded the members that there had been a much more recent earthquake than that of ten years ago, *viz.*, in December, 1896.

Mr. JOSEPH DICKINSON: The earthquake, so-called, of the 27th February, was felt at my house at Pendleton, a little after ten o'clock p.m. I was myself in Ireland at the time, but my wife wrote to me to say that they had had a great fright, that articles in the house shook—ornaments on the chimney piece, and so forth—and she was afraid a book case was coming down. One of our members who lives on the Bolton road felt it distinctly; it was then exactly 10 o'clock, and he supposed it was an explosion in the Pendleton colliery workings. We all know that a heavy fall of roof in a mine will sometimes cause a great commotion of wind and blow air doors open; and of course there are such things as subsidences of the ground causing great tremor. There is in that neighbourhood an immense depth of sand, and a very slight displacement of the ground may cause a considerable movement, accompanied by movement in the sand. There is not the slightest doubt there was a great tremor of the ground in the Seedley district.

Mr. STIRRUP: The circumstance of this movement being felt at such a depth below the surface is one of the most interesting points, I think, and if any members have information as to the shock having been felt belowground I shall be very glad if they will send me the particulars. I purpose sending all the reliable information I can collect to Dr. Davison, who will collate the facts and try to support the theory which he, along with others, has advanced.

Mr. HOLROYD: I do not know what disturbance it may have made in the coal mines, but it certainly made a very considerable disturbance on the surface in the neighbourhood where I live, which is near the suspension footbridge at Peel Park. I was in bed when it took place, but awake. On feeling the vibration of the floor and of the bed, and hearing the rattle of windows, I got up and looked at my watch and I found that it was exactly a minute past ten.

My daughter came to the bottom of the stairs and called to me to know what I was doing. The conclusion I came to was that there had been an explosion in one of the neighbouring mines, or at the gas works. As far as my own actual experience goes, the floor distinctly shook; it was a very different kind of movement from the earthquake that we felt in December, 1896, because it was a continuous movement. The shock that took place in December, 1896, was one complete and apparently vertical movement and then all was over; it lifted my bed and dashed it down again, and was then past; there was no further tremor; but in the present case the vibration seemed to be lateral, travelling from West to East, and to continue for some short time afterwards, because I heard the windows rattle for quite a minute or more after I got out of bed.

OCCURRENCE OF A GYPSUM BOULDER AT BLACKPOOL.

Mr. Stirrup said: We have lying on the table a pamphlet, with photograph, kindly sent by the author, Mr. T. Mellard Reade, F.G.S., of the great gypsum boulder of Great Crosby. It is certainly a remarkable boulder, mainly on account of its composition and large size. The country about Crosby, where this boulder was found, is altogether flat, and covered with a deposit of boulder clay, from which bricks are now being made. The ground is very little above sea level. This boulder was found 12 feet below the surface in digging the clay to make bricks. It weighs some 13 tons, and you will obtain some idea of its magnitude from this photograph. I do not know that we have any account of any other boulder of the same character, and of that size, having been found in Lancashire. Full particulars as to the dimensions, weight, &c., of the boulder will be found in Mr. Reade's pamphlet. The difficulty is to know whence it came. Mr. Reade suggests that it came from the neighbourhood of Whitehaven, as most of the other associated erratics are from a northern source. On reading Mr. Reade's pamphlet, it reminded me that some twelve months ago, when I was staying at Blackpool, I picked out the lump or small boulder of gypsum, now lying on the table, from the clay cliffs there. That is some distance further north of the locality of Crosby. Such boulders are unusual, I believe in this boulder-clay, for although I have rambled along those cliffs many times I do not remember coming across a gypsum boulder before. Of course this is a very small specimen when compared with the Crosby boulder, but still it may give some idea of the direction of drift, and in that respect it is interesting as bearing out the suggestion mentioned by Mr. Reade as the starting place of the boulder found at Crosby.

Mr. Stirrup then read the following paper :—

ON THE VALUE OF THE FOSSIL PLANTS OF THE COAL MEASURES AS STRATIGRAPHICAL GUIDES.

By Mr. Mark Stirrup, F.G.S.

At recent discussions among the members of this Society during the past year, and on several previous occasions, doubts have been expressed as to the value of the fossil plants of the Coal Measures, either as guides in the determination of geological horizons or as aids in the correlation of neighbouring or far-separated coalfields.

In order that these opinions of the inadequacy of fossil plants as records of geological age or succession in time may not obtain currency among the members, and to show that the balance of evidence is quite preponderant on the opposite side, the following notes and remarks are offered, not only as the expression of my own personal views, but also of that of others, whose claim to authority in such matters is unquestionable.

Another consideration weighs with me and impels me to the refutation of these doctrines of the nullity or uselessness of Coal Measure plants as tests of geological age, inasmuch, as the Society has, under its direction and supervision, a sub-committee whose object is the systematic collection of the fossils of the Coal Measures, bed by bed, for the very purpose of the identification and correlation of the various seams of our local coalfields, wherever possible.

Much has been said and written on the comparative value of different groups of fossils as proofs of geological age, specialists often rating with a higher appreciation the value

of the particular group of organisms upon which they may happen to be working.

It is true the higher the group in the scale of organization, whether in the vegetable or in the animal kingdom, and the higher the degree of the specialization of its members, so much the more is the value of such forms to determine geological horizons or stages of evolution.

In the Carboniferous Formation however, it would be as useless to look for dicotyledonous plants as it would be in vain to search for representatives of the mammalia, therefore we are perforce driven to fall back upon that group of fossils which is the predominant feature of the Coal Measures, namely its plant remains.

That special characters distinguish the plants of the Palæozoic epoch from those of the Mesozoic age is a fact recognised by geologist and botanist alike, and it is only applying the same guiding principles to finer issues, when an attempt is made, to determine by the same means, the order of succession of a series of beds in any particular coalfield or special locality.

It must not be understood that in urging a closer acquaintance with the fossil plants of the Coal Measures that I by any means wish to undervalue any help that may be got from the presence of other fossils, but seeing that plants are the most characteristic element of organic life of the period it is on their order of occurrence and distribution that our classification and correlation must be mainly based. Neither do I wish to depreciate the value of any help that may be derived from the lithological characters of the strata, the physical structure and texture of coals, characters which, in the hands of the practical miner, are often a helpful guide; but it must be borne in mind, that sub-divisions based on lithological characters alone must be always uncertain, owing to

their liability to change in a limited area. Moreover, lithological characters, from their very nature, are liable to come into existence, bearing the same aspect, at any point of geological time; on the other hand, any animal or plant, once extinct, never reappears in succeeding ages.

Doubts as to the value and use of fossil plants in geological chronology may arise from various causes, such as the known persistency of some types or species almost throughout the whole Coal Measures, thereby invalidating their diagnostic value in any attempt at zonal classification.

Other objections may be founded on the recognised deficiencies of our knowledge of the carboniferous flora as a whole; also the fragmentary state in which the fossils are usually found has led to many errors of classification and nomenclature, such as when parts of the same plant have been assigned to different species; errors which have been corrected by subsequent discoveries.

Admitting all these doubts and objections as well-founded, to what does the argument point, but to the necessity of a more rigourous and critical study of the fossils and their position in the rocks, in order to learn what a more minute examination might reveal of their ancient history.

The question of the order of succession and geographical distribution of the plants of the Coal Measures has received more attention in several of the continental coalfields, as also in the United States, than with us, the result of which has been the possibility of using certain groups of fossil plants or rare species as indicative of special horizons, a resource of much value in explorations in disturbed and faulted districts.

That this is no mere illusory or academic statement I shall be able to prove by giving a well-known recent instance of the practical value of such special research when applied to coal exploration.

Why then, may I ask, should the British coalfields rest in this inferior position to those of some continental areas? Is it that our geologists or palæobotanists lack the energy or perseverance of their continental brethren, or is it that we are so rich in coal deposits that such special researches to which I have referred, have no value in the market?

Our Society has done some little in removing this stigma of neglect, but how much more might have been done, if more enthusiasm and zeal had actuated those members whose avocations enable them to help in this work, it is not for me to say.

The results of what has been done by our members have for the most part been published in the Transactions of the Society where lists of the plant fossils are grouped by districts, the critical examination and nomenclature being due to Mr. Robert Kidston, F.G.S. to whom the Society is much indebted for his voluntary labour.

I will now, with your permission, ask your attention to the published opinions of certain eminent scientific men on some of the points of the subject-matter I have ventured to introduce.

First, I have translated a few paragraphs from the late Prof. Schimper's Treatise on Vegetable Palæontology, giving his views on the application of vegetable palæontology to geology.

Chap. ix., p. 101. "Not only has each formation its characteristic plants, but almost each of its subordinate beds may be recognized sometimes by the absence of one species and the presence of another, sometimes by the predominance of one type, which in other strata plays but a secondary role. One understands of what importance this fact may become in coal exploitations, where each bed represents a horizon, whose continuation may be able to be

recognized when it comes to be interrupted by a fault or any other dislocation of the ground. Long since it has been observed that each layer or stratum of one and the same coal district has its particular flora, presenting a special character, at the same time that it does not differ from others in all its details. Thus a species common in one bed, may be very rare, or be wanting altogether in a neighbouring bed, which excepting this detail, is in other respects similar. It is known also that when a species becomes extinct, it is for ever; the genera follow the same law, no error is thus possible under this head. The *Calamites radiatus* (Brongt.) characterizes the lower members of the Coal Measures, which form the passage between the Devonian strata to the productive coal formations: as this fossil has never been met with in the middle and upper beds, we are authorized to admit that it always indicates the commencement of the coal epoch and a formation in which the mineral coal is neither abundant nor of good quality. On the other hand, the *Calamites gigas* indicates the end of this epoch or rather the beginning of the Permian.

"Never have traces of *Stigmaria*, *Sigallaria*, and *Lepidodendron* been met with in formations more recent than the Lower Permian.

"Thus palæontology has been the means of fixing the geological position of the coal deposits of Savoy, containing impressions of these and other coal plants, in the series of Palæozoic formations, a position which had been opposed by some celebrated geologists.

(Page 104). "It will be seen by these examples of what utility vegetable palæontology may be to geology, and even to industry. But this application would also lead to grave mistakes if it were not used with the greatest prudence and with data capable of no equivocation. To generalize beyond measure would be as injurious as to take away its value in

restricting it in too narrow limits. We have certainly in fossil plants types which are as sure guides as those of the animal kingdom called tests, but there are also a great number which do not present the same certainty, because their forms are less decided, less accurately known, or because the limits of their geological distribution are not yet determined."

(Page 105). "Up to the present time nearly all the palæophytological discoveries have been simply due to chance. It is rare that regular and persistent excavations have been made in fossiliferous ground like those undertaken for the purpose of clearing ruins or discovering inscriptions."

"They have been explorations purely industrial which have opened out the materials upon which men of science have seized. Nearly all those who collected them saw in them but simple curiosities and placed them for this reason in the collection of amateurs where they are often lost to scientific study. Moreover, those who collected them on the spot being generally only ordinary workmen, took interest only in striking pieces and left all the others to be lost. One cannot think without regret of all that has been lost, of all the precious material belonging to the Carboniferous epoch that is still being lost."

"If we had only the one-hundredth part of the interesting remains destroyed by the pick of the miner, buried at the bottom of mines, or, lastly, thrown on to the refuse heap, where atmospheric agencies reduce them to powder, the coal flora would be nearly as well known as that of our own day."

I have in the preceding extracts from the valuable work of Prof. Schimper, the eminent palæobotanist, brought before you the botanical aspect of the question; and although you may not find anything positively new in the Professor's opinions, nor advice differing from that which has on previous occasions emanated from the Sub-Committee for fossil collection, yet I think the repetition of such

opinions will not be without their efficacy at a time when there is apparently a tendency to ignore the just importance of fossil plants.

Mr. R. Kidston in his address to the Royal Physical Society of Edinburgh in 1893, "On the Divisions of British Carboniferous Rocks as determined by their Fossil Flora,"* supports, by strong evidence from various sources in Great Britain, the opinion of the value of the fossil plants of the Coal Measures in the identification of strata. He moreover gives the following striking example, which is not by any means the only one, of the superiority of fossil plants to molluscan tests in determining horizons. "When sinking a shaft of the Hamstead Colliery, Great Barr, near Birmingham, 450 feet of red and purple shales, marls, and sandstones were passed through before meeting with the Middle Coal Measures. These upper rocks had been mapped by the Geological Survey as Permian; but from the evidence derived from the plants, which were carefully collected by Messrs. F. G. Meacham, M.E., and H. Insley, who were in charge of the work, it was shown that these shales belonged to the Upper Coal Measures.*

"From the Mollusca met with, Dr. John Young identified the following:—

Productus semireticulatus, Martin.
Productus scabriculus, Martin.
Edmondia rudis, M'Coy.
Schizodus sp. allied to *S. carbonarius*, Pork.
Modiola lingualis, Phill.
Anthracosia Urei, Flem.
Leda attenuata, Flem.
Goniatites sp. allied to *G. excavatus*, Phill.

* Proc. Roy. Phys. Soc. Edin., Vol. XII., 1894.
* See Trans. Roy. Soc. Edin., Vol. XXXV., p. 317, 1888.

Leaving out of consideration those individuals which are only generically identified, two of the species, *Modiola lingualis* and *Leda attenuata*, have been recorded from the upper beds of the Calciferous Sandstone series; *P. semireticulatus*, *P. scabriculus*, and *Edmondia rudis* are frequent in the Carboniferous Limestone series of Scotland; while *Anthracosia Urei* is generally restricted to the Lower Coal Measures. Anyone judging of the age of these rocks from the Molluscan remains, would, without doubt, class them as Lower Carboniferous, whereas they are certainly of Upper Coal Measure age.

Similar facts and opinions have been summarised in an interesting preface to the catalogue of the geological exhibit at the International Exhibition at Brussels in 1897, written by M. R. Zeiller, of the School of Mines, Paris, at the request of M. G. Schmitz, Director of the Geological Museum of the Belgian Coal Basins at Louvain.

A copy of this catalogue, published for the use of visitors to the Exhibition, was sent to me at the time by my friend, M. X. Stainier, Professor of Geology at Gembloux.

As the views of Prof. Schimper may be said to represent the botanical side of the question, I now propose to make some extracts from this pamphlet to prove the importance and practical utility of greater attention being paid to the study of fossil plants and their position in the strata. M. Zeiller, in recommending the practical use that may be made of fossils in explorations for coal, says, "that no one doubts the services that physics and chemistry are capable of giving to certain industries, but that geology and paleontology can fill a *role* as useful and as important in mineral industry is hardly ever dreamt of.

"The miner is ordinarily deemed sufficiently armed to recognize without outside help the order of superposition of

the different beds which he is working, to find them again from one side to the other of the faults which have affected them and disjoined them."

"Cases have, however, occurred, and the list would be rather a long one, where the application of the art of mining only, when in search of the continuation of a bed, has occasioned nothing but disappointment, and where the intervention of geological or palæontological science has been necessary in order to attain the desired result."

Mr. Zeiller goes on to remark that M. H. B. Geinitz had in fact as early as 1856 shown by his study of the coal deposits of Saxony that from one level to another the flora was gradually modified, and that these modifications would serve to determine in a sure manner the relative age of each group of beds. In 1877 M. Grand Eury applying the same method, at first to the coal basins of Central and Southern France, afterwards, although with less details, to all the other coal formations of Europe and North America, had laid down in an almost definite way the bases of a general classification founded on the study of plant impressions, the fossil animals being necessarily put aside, as much on account of their extreme rarity as of their too slight variations of form during the coal period.

In its turn, the French portion of the Franco-Belgian basin was made, in 1888, the object of a detailed study of a like kind, the result of which has been the means of establishing the palæo-botanic characters of the different groups of beds which constitute it, and of fixing the exact age of each of them; the value of the characters thus recognised, has, moreover been confirmed by the perfect agreement of the observations, made since then, by Mr. Leo Cremer, in the basin of the Ruhr, by Mr. R. Kidston, in the different coal-fields of England, and by Mr. David White, in those of the

United States; these different basins being, in whole or in part, contemporaneous with that of the North of France, having furnished the same groupings of species succeeding each other in the same order.

From a practical point of view, some important results have moreover been the means of affirming the utility of palæo-botanic researches and of attesting the confidence that may be had in the conclusions to which they lead.

Thus, notably, some 15 years ago, at the Grand Combe in the basin of the Gard (France), the study of the flora of the different groups of beds situated on both sides of a great disturbance (or fault) permitted the relative age of these groups to be ascertained, the direction in which they had been displaced by that disturbance, and has proved that the series of beds situated at the top, far from being the most recent, as stratigraphical observations led one to believe, was on the contrary the oldest. A boring afterwards made by the side of the fault wall has actually met with the top series at about 750 metres in depth, represented by thick beds of coal.

Barely a year ago, a brilliant success in the basin of Saint-Eloy, in Central France, crowned in like manner the researches taken in hand on the indications of M. Grand Eury, to whom the examination of the fossils collected at the outcrops, in a region vainly searched for the last 50 years, had been able to recognise that the productive level worked at the north-eastern end of the basin, ought to be found there at a much greater depth, the flora of the superficial beds of the region corresponding to a level considerably higher than that of the "Grande Couche de Saint Eloy." The discovery at 290 metres of a thick bed of coal has resulted in showing the exactitude of the indications drawn from palæo-botanic observations and in

recompensing the explorers who had not hesitated to accord their confidence in them.

Without quoting other examples, M. Zeiller passed on to speak of the value that this detailed study of the fossil flora has in giving clearer ideas on that often debated question of the mode of formation of coal.

Continuing, M. Zeiller says:—"Our knowledge of the coal formation has for the last twenty years made important progress, and the exploitation of mines has more than once benefited thereby; but whatever may be the generality of the results gained, it is clear that it is not the less necessary, in each basin, before passing on to practical application, to undertake a local detailed study, to be assured of the composition of the flora of each group, and to collect, with the view of the identification of every member of them, observations as complete as the state of the progress of the workings permits."

The extracts I have given will probably be sufficient to affirm the doctrines that I have endeavoured to enunciate, without introducing the evidence of other authorities in support, which, had time served, or necessity required, it would not have been difficult to produce.

Before laying aside M. Zeiller's pamphlet, I would like to ask the attention of the members to one of the closing paragraphs, with regard to the creation of a special Geological Museum of the Coal Basins of Belgium, an event which will recall our Society's connection with the Geological Museum at Owens College, and presumably encourage a continued solicitude for its welfare and pre-eminence.

The director of the Museum, M. Schmitz, in getting together the geological collection for the International Exhibition at Brussels, in 1897, being impressed with the

idea that the minute examination of the Coal Measures would be of great service not only to the palæontological and geological sciences, but also to the exploitation of mines, addressed a pressing appeal to the directors of all the collieries in Belgium, with the view of obtaining from each bed, from each seam, the methodical collection of specimens, principally plant impressions, destined to constitute a special Museum of the Belgium Coal Basins.

Such a favourable and ready response was made to this appeal on the part of colliery proprietors and private individuals that the now largely increased collections demanded larger space for their accommodation,—a new building had to be provided, and is now established at Louvain by the help of the same generous donors, and I believe was opened to the public last year.

The history of this Geological Museum is shortly as follows:—Starting with a modest collection in 1890 at the College Saint Servais, at Liége, owing to considerable additions, it had to be moved to more commodious quarters at the College Notre Dame de la Paix, at Namur, in 1892, and again in 1897 to the special building that has since been erected at Louvain, where the collections of upwards of 6,000 specimens may now be inspected.

In bringing my remarks to a conclusion, I trust the evidence I have adduced of the use that may be made of fossil plants as stratigraphic or time marks will be sufficiently convincing as to direct the attention of members to the importance of the subject, and be the means of leading to some valuable results.

There are other points of interest connected with the study of fossil plants in their relation to geology, such as to what extent can fossil plants be used as tests of climate of past epochs; or, again, how far similarity of species and

the like order of succession may indicate contemporaneity in time in widely separated areas; but questions such as these I have avoided, as having no practical application to exploration for coal.

Mr. GARFORTH, in moving a vote of thanks to Mr. Stirrup for his paper, said: If we could look back on all the mistakes that have been made in sinking we should find that tens of thousands of pounds have been wasted. I happen to know Mr. Cremer, one of the professors in the School of Mines, at Bochum. I know he can give instances in his district where large sums of money have been saved by a regular and systematic course of inspection by a geologist. I fully endorse all the sentiments so ably put before us by Mr. Stirrup.

Mr. HOLROYD, in seconding the motion, said: Although I cannot quite agree with all that Mr. Stirrup has said as to the value of fossil plants in comparison with the fossil animals that are found in the carboniferous strata, yet I have no doubt if the fossils were examined in a more systematic manner they would be exceedingly useful, at all events in the particular localities in which these fossils were found. I do not believe, myself, that the fossils from any one locality could be relied upon as forming horizons or zones which might be used as guides in other localities; and that is the point on which I beg leave to differ from Mr. Stirrup.

The motion was unanimously passed.

Mr. Holroyd exhibited a specimen of *Neuropteris Scheuchzeri*, a species which, he remarked, was supposed to have been very rare, and characteristic of certain beds in the coal measures. It had been found, however, on further research, not to be so. It was fairly common throughout the entire Carboniferous series.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VII. VOL. XXVI. SESSION 1898-99.

An ORDINARY MEETING of the Members was held on Tuesday, April 11th, 1899, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. JOHN S. BURROWS in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. WILLIAM DOWNHAM, F.G.S., 65, Grenville Street, Stockport.

Mr. LAWRENCE PILKINGTON, South Garth, Eccles Old Road, Pendleton.

Mr. DICKINSON made the following remarks on "Boiler Explosions."

BOILER EXPLOSIONS.

By Mr. Joseph Dickinson, F.G.S.

The wreck of the Stella steamship, on March 30th, by striking the Casquet Rocks off Alderney Island, and the attendant great loss of life, elicits our sympathies on behalf of all the sufferers. The cause will, no doubt, be carefully investigated, but the statements whether the steam boilers did or did not burst are at variance. The strongest evidence appears to show that explosion occurred. I am much impressed by what Mr. Leonard Reuss is reported in the *Times* of April 8th to have stated; he seems to have acted throughout as a man of nerve, and without delay returned to his duties in London. From his statement, he with another person, almost at the last, threw overboard into the sea one of the airtight deck seats and dived after it, and, having with several others laid hold of it, marvellously escaped. He was only about 12 feet from the ship, within the suck, when she sank. He says distinctly there was an explosion, which the people who had got off in the boats deny, and that they were not near enough to know. In confirmation, he adds, that one of the ship's firemen, who found his way to the floating seat was burnt and cut about the face and body.

I have investigated many boiler explosions, and have been within a few yards of one where the boiler shot about 100 yards away, and, ripping the piping off two adjoining boilers, and the roof and walls of the boiler-house, sent missiles and water into the air, taking a long time in falling. I instantly lay down under the projecting upper part of a long iron Welsh coal tram, and when all was over emerged

with some cuts, and, strange to say, wet to the skin without being scalded, the water having apparently been high enough in the air to cool, but one person was scalded to death and another killed. I have also been near, and in full view of, an uncovered range of boilers, two with steam up, but the other erroneously supposed to be empty and disconnected, from which the fitter who lost his life on unscrewing the man-hole allowed the steam from the others to rush out. I have also been at the intentional experimental bursting with water pressure of two disused boilers. I can, therefore, say that the bursting with steam is not like the crack of artillery, but is more like a heavy waggon running amain down a steep road; and that the bursting with water pressure gives out only a not loud thud. The persons rowing away in the boats may therefore not have heard the explosion which Mr. Reuss and others have described.

The point to which I wish to call the attention of our practical members is that this is not the only case I have heard of where a boiler has burst when cold water has come upon it, on sea and land. One instance which came under my notice, two or three years ago, was at the flagstone quarries and mines at Britannia, near Bacup, where an uncovered vertical boiler burst immediately after the falling upon it of a heavy thunder-shower of rain. Covering boilers has many advantages, but I have known an instance where the uptake of a vertical boiler having set the roof on fire, a part of the roof lowered so as to prevent the safety valve from acting and the boiler burst.

THE CHAIRMAN: What should make the boiler burst when the ship sinks? Is it that the water condenses its steam suddenly, and so causes a vacuum to form within the boiler which then becomes compressed?

Mr. HOLROYD: I think you are quite right as to the cause of what might very well be called an "implosion," because if you pour cold water on any vessel which contains a large quantity of steam, you at once condense all or some of that steam, and so cause a vacuum within the boiler. The pressure of the atmosphere outside will force in the plates.

Mr. HALL: I should think from the account I saw, the boilers did not burst, but the decks blew up, as they naturally would, on account of the ship getting filled with water. The engineers' account seemed to put an explosion of the boiler out of the question. They said naturally that the water getting into the ship put the fire out, and there would be an end of the pressure; and what was there to burst the boiler? A steam pipe might be broken off, but I imagine the boilers themselves would not burst.

Mr. G. H. MORTON, F.G.S., then exhibited his new Geological Map of the Liverpool district, and read the following paper upon it:—

DESCRIPTION OF A NEW GEOLOGICAL MAP OF LIVERPOOL.

By Mr. G. H. Morton, F.G.S.

In 1860 I made a Geological Map of the area under Liverpool, and two others in 1875 and 1885, but there was so much uncertainty as to the direction and continuity of the numerous faults, that I gave up any further attempt as hopeless. Still I continued making observations, and plotted down the results on the 6-inch Ordnance Map as soon as it was published.

If such observations could be continued for several hundred years, it is a question if future exposures would be sufficient to enable an absolutely correct map of the area to be made. The only effectual course would be to remove all the buildings and streets, and to clear away the drift deposits and rubbish from the surface, and then to drive in stakes along the faults after making such excavations that might be necessary. Such a course being impossible, the only method is to continuously make all the observations to be derived from such excavations for buildings, roads and railways as may be exposed from year to year over the area covered by the city and the country closely surrounding it.

The officers of the Geological Survey fully understand the difficulty of making a correct map, and Mr. A. Strahan, F.G.S., expressed his opinion that such a map could never be considered to be finished, but would have to be corrected from time to time with the gradual progress of observations. The difficulty is shown by the Geological Map of the district published by the Survey, which shows successive alterations.

The Quarter Sheet 79 N.E., containing Liverpool, was first published in 1854, and after some correspondence with Prof. E. Hull, F.R.S., he visited Liverpool at the suggestion of Prof. Ramsay, and went over the ground with me. The result of his visit was to considerably lower the base of the Keuper and to make the map much as it now appears, for only very slight alterations have been made in it since.

Forty years having elapsed since I began to make observations for a local Geological Map, without being able to obtain any information respecting several parts of the area, it seemed desirable that what had been done should be recorded in a permanent form. In order to carry out this idea, I determined to produce a Geological Map of Liverpool, showing the sub-divisions of the Trias, and the numerous faults, forty-one in number, but indicating all the places where I had actually seen them by means of *red circles* on the downthrow side of each. Where a fault has been seen in two or more places its direction may be considered finally ascertained, while those that have been seen in only one place *may* run somewhat differently to the direction shown on the map. The occurrence and direction, however, of some of the faults which have *not* been actually exposed, where they form boundary lines between sub-divisions of the Trias, are as certain as those that have been seen in excavations. As examples of such faults, the Netherfield Road and Shaw Street fault, the Exchange fault, and the Tue Brook and Wavertree fault were all accurately traced on the first maps of the Geological Survey, although none of them could have been seen by Prof. Hull when he surveyed the district in 1854.

Broken lines are introduced on the map to indicate faults whose position is doubtful, where the country is deeply covered with drift, and little if anything known about the underlying rock.

The strata forming the sub-divisions of the Trias may be still examined in many places, but in others it would necessitate years of waiting for an opportunity of seeing the rock, where I have had frequent means of doing so during the last 50 years.

LIST OF THE FAULTS SHOWN ON THE MAP.

With the Hade and probable Downthrow of each.

1. Netherfield Road and Shaw Street Fault.
   Hade W., 1000 feet, but about 600 feet in Toxteth Park.
2. Stanley Road Fault.
   Hade W., 20 feet.
3. Hawthorne Road and Scotland Road Fault.
   Hade W., 150 feet.
4. Latimer Street and Church Street Fault.
   Hade E., 600 feet.
5. Castle Street Fault.
   Hade E., 250 feet.
6. Central Station Fault.
   Hade W., 100 feet.
7. Lime Street Fault.
   Hade W., 300 feet.
8. Hotham Street Fault.
   Hade W., 90 feet.
9. Russell Street Fault.
   Hade W., 80 feet.
10. Trowbridge Street Fault.
    Hade W., 50 feet.
11. Great Newton Street Fault.
    Hade W., 30 feet.
12. Mount Pleasant Fault.
    Hade E., 6 feet.
13. Peach Street Fault.
    Hade W., a few feet.
14. Jasper Street Fault.
    Hade W., a few feet.
15. Vine Street Fault.
    Hade W., 100 feet.
16. Goulden Street Fault.
    Hade W., 4 feet 6 in.
17. Edgeware Street Fault.
    Hade W., 3 feet.
18. South Hunter Street Fault.
    Hade S.E., 100 feet?
19. St. James' Cemetery Fault.
    Hade W., 200 feet.
20. Hardman Street Fault.
    Hade W., a few feet.
21. Philharmonic Fault.
    Hade W., a few feet.
22. Smithdown Lane Fault.
    Hade S.W., 150 feet.
23. St. Patrick's Fault.
    Hade W. 25 feet?
24. Cheshire Lines Fault.
    Hade W., 25 feet.
25. Cross Fault.
    Hade N., 30 feet?
26. Two Gasometers Fault.
    Hade W., 20 feet.
27. Eight Houses Fault.
    Hade W., 50 feet.
28. Graving Docks Fault.
    Hade W., a few feet.

29. Shipwright's Yard Fault.
Hade W., 50 feet.
30. Drainage Outlet Fault.
Hade W., 50 feet.
31. Borough Boundary Fault.
Hade W., 50 feet.
32. Dingle Bank Fault.
Hade W., 20 feet.
33. Dingle Point Fault.
Hade W., 300 feet?
34. South Shore Fault.
Hade W., a few feet.
35. St. Michael's Fault.
Hade W., a few feet.
36. Tue Brook and Wavertree Fault.
Hade W., 600 feet.
37. West Derby Fault.
Hade S.W., 600 feet.
38. Croxteth Fault.
Hade S.W., 1,500 feet?
39. Whitefield Road Fault.
Hade W., a few feet.
40. Olive Mount Fault.
Hade S., very uncertain.
41. Museum Fault.
Hade E., 2 feet.

The amount of the dislocation of the faults is given to show their relative importance rather than the actual figures, though in many instances it has been carefully ascertained and in some actually measured.

It is evident from the map that the most intense faulting is in the Keuper, between the boundary faults forming the trough into which that formation has subsided. The Bunter on each side of the Keuper has been very little disturbed, and the faults are few in number. It is remarkable how few occur in long sections, such as that at Olive Mount, where there is only one small fault along the whole of the railway cutting. In a paper read before the Liverpool Geological Society* I described the faults in the centre of the town, and referred to the difficulty of ascertaining the continuity and the connection of the faults with each other. Since then something has been done to overcome the difficulty, but much still remains to be explained before the relation of the faults and the principles of the fracture can be satisfactorily worked out. Although most of the faults run north and south, those about the centre of the town run a little to the east or west of the main direction, and it is obvious that

* "Proc. Liverpool Geol. Soc.," Vol. VI., p. 294.

some run into others, or are cut off and thrown out of their course by faults having a different direction.

Some slight corrections may ultimately be found necessary as to the directions given to these Keuper faults, where they were obtained from sections in railway cuttings and other excavations where only 5 or 10 yards of the fault could be seen.

As it would be too expensive to publish the Map, it is my intention to present it to the Free Public Library of Liverpool, and as it has been already copied at the Geological Survey Office, in London, no doubt it may be also consulted there.

The following is a copy of the acknowledgment from Sir Archibald Geikie:—

Geological Survey Office, London,
5th January, 1899.

My Dear Sir,

Will you accept my best thanks for the permission you have so kindly given to the Geological Survey to take copies of the Six-inch Geological Maps of Liverpool, which your long residence in the town and your constant observation on the progress of all excavations have enabled you to make. The information is of special value to us, being such as it would have been impossible to obtain in any other way.

Believe me to remain,
Yours very truly,
ARCH. GEIKIE.

Mr. STIRRUP said: I have very great pleasure in moving a vote of thanks to Mr. Morton, one of our Honorary members, who has done us a service in making his map of Liverpool better known to us. We have evidence, in what he has done, of the value of amateur work to the State Geological Survey. Of course, in a crowded city like

Liverpool or Manchester, it is only with the greatest difficulty we can get to know what is the solid geology below; it is only in excavations, when foundations are being taken out for buildings, or in tunnelling or making sewers, that we can learn much about the strata. Manchester, of course, is under much the same difficulty as Liverpool in that respect. One must always look upon the government maps as affording the best information at the time of the Survey, though subject to alteration as additional discoveries are made, such as Mr. Morton has pointed out.

Mr. GERRARD: I have very great pleasure in seconding the motion. I listened with great interest and pleasure to Mr. Morton's account of the faults in the newer strata about Liverpool. I had no idea there were such faults. To the casual observer they are not to be seen, and our knowledge of them is a testimony to Mr. Morton's hard work and close observation.

Mr. DICKINSON (who had taken the Chair) said: The paper deals with a subject that is of considerable value to this Society. We have the old Geological Maps, published in 1854, and these, through Mr. Morton's instrumentality, were corrected. We have also the Geological Maps and Sections which Professor Ramsay gave in evidence before the Coal Commissioners in 1868, and these differ very materially from the map which Mr. Morton has now laid before us. I should like to ask Mr. Morton if he will allow us, as he has allowed the Geological Survey in London, to take a copy of this Map and to mark it on our six inch map of Liverpool. I would also like to ask Mr. Morton which of these faults it is that constitutes the great boundary line for the well-water which is so largely obtained in Liverpool. I have heard Mr. De Rance state in this room that there is one large fault which runs through Liverpool, and it is only on one side of that fault that they get the large feeders of water. It would be interesting to know which of these numerous faults that

main fault is. I would also like to ask Mr. Morton whether he considers these Keuper Marls which he has described, represent the Saliferous Marls of Cheshire, in which the salt is found, or whether it lies below those Marls. The Keuper shown on this map seems to me beset with faults running in various directions, but there is not in any salt mine in Cheshire a single fault to be found. I have been in them all and can speak with decision on that point.

Mr. MORTON, in responding, said: I am extremely pleased to find that so much interest has been taken in the paper, as is very evident from the number of questions asked, and the remarks made upon it. As to the presence of marks of striation—or "slickensides"—of course they occur everywhere, in all the faults. Some of the faults are of considerable width, and I measured one 19½ yards wide, but that was an extreme case, where the sides had fallen in. Sometimes they are only a few inches wide. Then the dislocations seem to me to be very similar to what occur in the Coal Measures in the neighbourhood, towards Prescot and Wigan. There is no doubt that the Trias originally covered the Coal Measures to the East and North East of Liverpool, and I believe these faults dislocated the Coal Measures at the same time; and the age of the faults in the latter is also post-Triassic. All the faulting occurred at about the same period.

In obtaining the directions of the faults, the method I have adopted in Liverpool, is to make observations with regard to surrounding buildings, and not to depend on compass bearings, which are liable to error. Then as to the water supply, I have had a great deal to do with various wells, and my impression is that some of the water we have in Liverpool, comes from the sea. I know that this view is objected to, and chemists say it is impossible. The water, they maintain, could not lose its chloride of sodium. But some years ago, Dr. Isaac Roberts made a series of experiments by forcing water through four or five feet

of sandstone, and it made an appreciable difference in the saltness. Now if you could force sea water through 400 or 500 feet of sandstone, it would, I apprehend, lose a good deal of its saline ingredients. It is, moreover, well known that the old wells in the neighbourhood of Liverpool are gradually becoming brackish, and I believe that the wells at a greater distance will suffer in future years. The amount of water we get from the sandstone at Liverpool far exceeds the original estimate, and I cannot come to any other conclusion but that it is in consequence of water which filters from the sea. The Green Lane well has yielded 3½ million gallons a day for a very long period. It was sunk by a Company 60 years ago; I do not know why they made it there; but it so happens it is on a great fault and that I believe explains the copious supply. Then as to the age of the marls, there is no doubt they are the Saliferous Keuper Marls. Pseudomorphous salt crystals are common in them. As to the thickness of the beds (represented in the exhibited Section,) all have been proved by borings in the neighbourhood of Liverpool.

I do not know any part of the country where the Trias has been pierced to the same extent as at Liverpool—by tunnelling under the Mersey and other excavations.

As to Mr. Dickinson's question, I am considering whether it would be possible to get the map copied.

Mr. STIRRUP: The boring at Bidston—was that for water or for coal?

Mr. WELLS: There were two at Bidston; the one referred to is on the other side of Bidston Hill.

Mr. MORTON: I do not know anything about that boring, excepting that it was made in search of Coal. We could get no information whatever from the person who made it.

Mr. WELLS: Are the wells to be found in the Keuper?

Mr. MORTON: Yes, originally they were principally in the Keuper. It is rather remarkable that at Schweppe's Soda

Water Manufactory they have a well in the Keuper, and up to ten years ago they were using the water from it. They had it analysed and it was found satisfactory.

Mr. WELLS: If Mr. Morton will be kind enough to leave the sheets I shall be most happy to copy them for the benefit of the Society. I think they contain very valuable information.

Mr. MORTON: A question was asked as to the amount of dislocation. I give a list of the faults in the paper. There are several of only a few feet; the others vary, being 600 ft., 300 ft., 100 ft., 90 ft., 30 ft., and so on. They are very similar to those in the Coal Measures.

Mr. STIRRUP: I presume all these particulars appeared in the new edition of Mr. Morton's "Geology of Liverpool."

Mr. MORTON: Not all of them. The map which appears in the new edition is not so complete as that now before you.

Mr. DICKINSON: Which of these beds does the Mersey tunnel pass through?

Mr. MORTON: The Upper Hard Sandstone. In going through it not a single pebble was found, and the officers of the Geological Survey said that the name formerly given to the Pebble Beds, was absurd.

Mr. DICKINSON: The rock which is so conspicuous in Lime Street Station is the Keuper is it not?

Mr. MORTON: It is the base of the Keuper.

Mr. WELLS: The Runcorn quarries—what are they?

Mr. MORTON: They are Keuper, and they contain footprints similar to those found in the Keuper at Liverpool.

Mr. W. F. HOLROYD, F.G.S., read a paper by Mr. J. BARNES, F.G.S., and himself "On the Influence of Subterranean Excavations in Limestone Areas, and a Consideration of the Atmospherical, Physiological, and Hygienic Conditions produced thereby."

ON THE

INFLUENCE OF SUBTERRANEAN EXCAVATIONS IN LIMESTONE AREAS AND A CONSIDERATION OF THE ATMOSPHERICAL, PHYSIOLOGICAL, AND HYGIENIC CONDITIONS PRODUCED THEREBY.

By Messrs. J. Barnes, F.G.S., and W. F. Holroyd, F.G.S.

Illustrated by Diagrams, Photographs, and Specimens.

The romantic scenery of Mountain Limestone areas is well known to all geologists, whether viewed from the point of its lofty tors of precipitous limestone, such as may be seen in the Winnatts at Castleton, or the High Tor at Matlock, or from the point of the artistic beauty of the winding dales, such as Beresford Dale, Cave Dale, Dove Dale, or the lesser known ones of Deep Dale, Narrow Dale, or Glutton Dale, so rich alike in geological, mineralogical, and botanical treasures.

The water, which falls in the form of rain and snow, in a limestone district soon settles through the soil and subsoil, and enters the joints and crevices of the rock. Being more or less charged with carbonic acid it acts upon the smaller joints of the limestone, eating the adjacent sides away, and gradually enlarging them. This action we have already described at some length in a former paper on "The Mountain Limestone Caverns of Tray Cliff Hill, Castleton, Derbyshire."* In this manner spaces are often formed in the joints, generally

* Trans. Man. Geol. Soc., Part X., Vol. XXIV.

in the form of a rhomboid, and the water appears to have enlarged its path in all directions, above, laterally, and below. (Refer to diagrams of acid eaten joints in limestone.)*

It is to the action of such acidulated water also that the irregularly shaped blocks of limestone often used as rockeries are due, being eaten into fantastic and grotesque forms, and sometimes having holes of large size eroded through them.

The subterranean cavities thus formed are sometimes partially, and sometimes wholly, filled with water, and a progressive action is maintained until a system of intricate underground drainage is established of vast extent and influence.

In other places in the limestone, and particularly in the joints at the apex of an anticlinal fold, which are much opened, we have by the same process, circular and generally somewhat vertical holes formed, which are known as "swallow holes." They have been formed by the action of the carbonic acid in the water, enlarging a series of joints, which were more or less vertical, and in a line above each other, until streams of considerable magnitude are capable of being swallowed up by them. (See diagram of formation of a "swallow hole.")*

The extent of these swallow holes is very considerable, one, in the Blue John Mine, was found to be 49 feet in vertical height and from 3 to 4 feet in diameter. This shaft did not open out to the surface, but to the end of a large chamber. The sides of this swallow hole are draped with white or buff stalactitic wall covering or dripwork, and at the top of the cavern above it are numerous pendent

* Trans. Man. Geol. Soc., Part X., Vol. XXIV.

stalactites, showing that its formation is due to percolating water charged more or less with carbonic anhydride.

The underground passages may extend for miles, and ramify in all directions, many of the limestone hills in Derbyshire being completely honeycombed with large chambers connected by swallow holes, through which water passes, and traversed by rapidly moving streams of water of great volume, as for example Tray Cliff Hill, Cow Low, and Hurd Low at Castleton.

See also M. Martell's "British Caves and Spéléology," Marble Arch (Ireland), and Bagshaw Caves, at Bradwell, and Castleton Caves, Derbyshire.

There are also three similar caves at Eyam and Stoney Middleton, which have not yet been scientifically explored, all connected and traversed by a large stream of water.

As a proof of the great extent of these subterranean passages at Castleton, we may say that we have placed a quantity of colouring matter in a roaring stream in Speedwell Mine, where there is a vast natural opening, and it has only been noticed, after a lapse of 24½ hours, emerging from the stream of the Russet Well beyond Peak's Hole. As the stream moves rapidly the course may possibly extend for many miles along the underground passages, winding about among the rocks until at last it reappears at a lower level. Many attempts have also been made, but hitherto without success, to ascertain the exit of the water from the stream flowing through the Blue John Mine. It goes on descending the waterways until it is impossible to follow it further, and although colour has been put into it and careful search and inquiries made, its reappearance has never been noted.

Thus we see that carbonic acid derived from the atmosphere, and to a much larger extent from the decomposing vegetable matter upon the surface of the soil, plays a highly

important part in the economy of nature, inasmuch as it is capable of dissolving the solid limestone which was once formed by organic means at the bottom of the sea, and of carrying some of this lime in solution along the rivers to the sea again, in order to be utilized by the marine animals in forming their hard parts, thus revealing to us an interesting cycle in nature.

We have made some experiments to ascertain the rate of solution of calcium carbonate in water charged with carbonic anhydride, and find that when a water is fully charged, and is allowed to act upon a limestone, the maximum rate of the solubility of the limestone is 64 grains per gallon at 15° C., and the specific gravity of the solution is 1·0022.

The volume of this underground water depends of course upon the rainfall of the district, and where this is large, the geological work accomplished is very considerable, and of great importance to the well-being or otherwise of the population on the surface.

The rocks being thus permeated by water, give rise to what is known as the water level of the district, which may be near the surface, as it is when the formation below consists of shales and clays, or at a considerable distance below, as in the case of a limestone district.

The amount which flows from the surface in streams, or which penetrates the ground, depends upon the configuration of the surface, the nature of the soil, the season and temperature, and most of all on the underlying rock.

"On the New Red Sandstone 25 per cent. penetrates into the ground; on chalk and limestone 42 per cent.; on loose sand 96 per cent."*

It is not advisable, however, to make use of water from limestone caves and fissures indiscriminately and without

* Lane Notter & Firth, "Hygiene," page 65.

it being regularly tested. It is liable to much contamination from organic decaying material washed into the caves—bodies of stray animals which have fallen into the fissures, or from some of the steep limestone cliffs and escarpments.

After having descended the opening of the Gulf of Padirac, M. Martel says, on page 264, "Les Abimes": "Let us pass under the arch. We hear, arising from below, a murmur! There must be water, cries Arnaud, there is the looked-for river! But shall we be able to follow it? In the dark gallery of which this gateway forms the entrance, is a heap of slippery and cracked clay inclined at 35°, the stony talus appearing to continue. There we are hindered by numerous carcasses of animals in a high state of decomposition, which have either fallen or been thrown into the pit. It is a veritable charnel house. What a horrid smell!" And again in France, with regard to sources of typhoid fever,* M. Martel says:—

"The epidemic of typhoid fever, developed by the accidental contamination of wells and sources, continues to manifest itself on all sides. Recently the attention of the Government has been called to the gravity of this fact by a question from M. le Dr. Labbé to the Minister of War, at the meeting of the Senate of 18th November, 1898. On this occasion M. De Freycinet has noted and recognised the grave danger that follows to the public health by the pollution of rivers and sheets of subterranean water. The interesting discussion provoked by this debate is to be found in the Official Journal of 19th November, 1898.†"

Some of the waters never reappear but reach the sea underground; others form springs, and come up faults and fissures, or emerge from a porous bed on the side of a dale or valley.

* F 123, Spelunca, No. 15, 1898, M. Martel.
† Accounts of the Proceedings of the Senate.

The blocks of limestone, being loosened by the removal of material from between the joints, and by the widening of the joints, often fall from the roofs of caverns, sometimes blocking the stream and compelling the water to find a new course. The distance from the roof to the surface of the soil is lessened by the action of the water and the falling of the roof, until at last the cavern is opened out to the sky, and irregular winding dales are thus formed.

Moreover, not only are the superfluous waters removed from the surface, but this removal brings about, along with other agencies, important Atmospherical, Physiological and Hygienic results.

As the water level is much below the surface, the soil and subsoil contain little moisture and much air. This is called "ground air," and it fills all the spaces in the rock not occupied by water; it varies with the rainfall, temperature, and barometrical pressure. The absorbing power of the soil for heat varies much according to the geological formation and colour, while the radiating power depends on the kind and thickness of the vegetation growing upon it.

The following figures, taken from Dr. Lane Notter and Firth's book on "Hygiene," page 183, give the expression of the respective powers which different soils have of retaining heat:—

Lime sand	100
Pure sand	95·6
Light clay	76·9
Gypsum	72·2
Heavy clay	71·1
Clayey earth	68·4
Pure clay	66·7
Fine chalk	61·8
Humus	49·0

As judged by the relative power for losing heat, soils appear to stand in the following order: clays, loams, marls, chalk, sand. Sands not only warm more rapidly than other soils, but also appear to retain heat better.

Now the temperature of the soil has a very important bearing upon health. From what has been said above it will be seen that a limestone rock, subsoil and soil, forms a warm ground. The warm ground has a direct influence upon the temperature and dryness of the atmosphere, and these again react upon the human body to an appreciably beneficial extent.

The members of this Society are aware that we have made many visits to Derbyshire, on pleasure bent, geological, hygienic and otherwise, and we have not only been intellectually occupied, but also physically benefitted in the matter of renewed health.

We had often been struck with the effects experienced in going from Manchester to Mountain Limestone districts, particularly Castleton; these effects being, first, a marked ease given to the respiratory organs; second, a very noticeable influence upon the functions of the renal organs; and thirdly, a powerful effect upon the skin, relieving it of moisture in a manner to be described later on.

We have made a number of observations upon the comparative presence or absence of moisture in the atmosphere, as compared with other localities, by means of the hygrometer, and find that as a result of the geological phenomena we have described, the air dries again very rapidly after rain.

Of course when there are heavy rains at Castleton the atmosphere is saturated as in other places, but extremes of dryness are greater there than we have observed here in Manchester, for here the wet and dry bulbs of the hygrometer

are often near together, which shows that the moisture in the air is near saturation point.

The greatest differences hitherto observed in Manchester are as follows:—

Date.	8 a.m.				12 noon.				4 p.m.			
	D.B.	W.B.	Diff.	%	D.B.	W.B.	Diff.	%	D.B.	W.B.	Diff.	%
May 30, 1898 ..	55	49	6	64	54	50	4	74	52	50	2	86
June 13 ,, ..	62	56	6	67	62	57	5	72	54	50	4	74
,, 16 ,, ..	61	55	6	66	62	58	4	77	61	57	4	76
,, 17 ,, ..	62	55	7	67	70	62	8	61	68	60	8	60
July 17 ,, ..	67	63	4	78	70	64	6	69	66	62	4	78
,, 27 ,, ..	64	59	5	72	68	60	8	58	66	60	6	68

The following observations show how rapidly the air can change in the district under notice (Castleton), even in an hour's time, after a heavy shower of rain:—

DATE, SEPTEMBER 4TH, 1897.

Time.	D. B.	W. B.	Difference.	Per cent. of humidity.
10-35 a.m.	55	51	4	= 74·5
10-45 ..	60	56	4	= 76
10-50 ..	52	48	4	= 74
10-55 ..	53	49	4	= 74
11-0 ..	53½	50	3½	= 80
11-5 ..	59	55½	3½	= 81·5
11-10 ..	60	54	6	= 66
11-15 ..	58½	53	5½	= 66
11-30 ..	60	55	5	= 71
12-15 ..	54	48	6	= 64

As an example of the greatest dryness of the air, we find on April 8th, 1898, dry bulb 72°, wet bulb 59½°; difference 12½°, or only 47 per cent. of humidity.

The following table shows the variation from August 11th to August 21st, 1898, at Castleton:—

Date.	8 a.m.				12 noon.				4 p.m.			
	D.B.	W.B.	Diff.	%	D.B.	W.B.	Diff.	%	D.B.	W.B.	Diff.	%
Aug. 11 ..	65	63	2	88	78	70	8	63	..	..	..	..
,, 12 ..	62½	60	2½	82	82	73	9	60	..	..	..	..
,, 13 ..	65	61	4	77	72	65½	6½	65	70	64	6	69
,, 14 ..	62½	61	1½	87	75	66	9	59	81	70	11	52
,, 15 ..	64	61	3	82	72	66	6	69	70	65	5	73
,, 16 .	64	60½	3½	78	74	68	6	70	80	72	8	63
,, 17 ..	61	58	3	82	76	68	8	63	78	69½	8½	62
,, 18 ..	58	55½	2½	84	69	62	7	64	64	59	5	72
,, 19 ..	56½	55½	1	90	60	59	1	88	62	61	1	90
,, 20 ..	61	60	1	90	71	66	5	73	77	69	8	63
,, 21 ..	64	62	2	88	79	72	7	67	68	62	6	68

The figures for August 14th are very instructive, for we find a difference in eight hours of 35 degrees of humidity. Compare also the mornings and afternoons of the 20th and 21st.

It is very rare that the percentage comes so low as 50. These figures show that the water passing off the land so much more quickly, renders the air drier, inasmuch as there is a smaller amount to evaporate, while in towns and places where the water remains on the surface the air continues nearer the saturation point for a much longer period.

In addition to this, 50 per cent. more water drains off undulating ground than from the comparatively level areas;

and so it comes about that even after three or four hours continuous downpour of rain, the water is carried off so quickly that the surface soil soon dries, and the atmosphere possesses a lower degree of humidity.

It may be said that the beneficial effects experienced are not altogether due to the difference in the dryness of the atmosphere, but partly due to the purity of atmosphere, and to the absence in this district of solid particles of dust arising from manufacturing and commercial pursuits. But it was found by us that it was possible to go to a district not on the limestone, but still where the air was pure, yet not so dry, and not obtain the same beneficial effects.

In most large towns not on the limestone, but on cold shales or glacial clays, the wet and dry bulbs of the hygrometer are often near together, indicating that the air has become almost saturated with moisture.

Now as to the physiological and hygienic effects produced on the body by the greater dryness of the air in a limestone district. The human body consists of two-thirds its own weight of water alone. The water acts as a carrier of poisonous excretory matter from the body, the three great excretory organs being the lungs, the kidneys and the skin. If any one of these fail in its appointed functions more work is thrust upon the other two. The quantity of watery vapour given off from the body is greatly influenced not only by the different degrees of muscular exertion and repose, but also under the ever-changing degree of moisture of the atmosphere. Speaking roughly, 10 oz. are given off by the lungs and some 20 oz. by the skin per day. This is equivalent to about 550 grains per hour. At an average temperature of 60° F., this means enough moisture is given off by the human body every hour sufficient to saturate 90 cubic feet of air, and this is from the lungs and skin alone.

The amount of aqueous vapour of course varies, but the chief cause of this variation is the varying quantity in the inspired air. In large towns, because of the impurity of the atmosphere, the lungs cannot do their proper work. First, we have dust, mechanical impurity, which clogs the delicate lung tissue and prevents the proper oxidation of the blood in the tissues. Then we have an excessive amount of carbonic acid gas, the result of manufacturing processes and the density of the population; and lastly, we have an atmosphere which is normally nearer the saturation point with water, consequently, the air which enters the lungs is almost as moist as that which returns from it, and thus more work is thrown upon the kidneys and the skin.

In the limestone districts the air being drier for a greater length of time during the day the lungs expire more moisture and receive more oxygen and purer air. Any cause which draws off a large quantity of fluid from the body through any other channels than that of the kidney, *e.g.*, the skin or the lungs, lessens the quantity of water in the urine and increases the specific gravity—for the amount of solids discharged by the kidneys daily is fairly constant. Thus in cold weather when perspiration is scanty, the discharge by the kidneys is most abundant and more dilute than in summer, when the amount of water vapour discharged from the skin is great. A healthy adult passes on the average about 50 fluid ounces or 2½ pints daily from the kidneys, the amount of solids in solution being about 2 ounces or 4 per cent. In towns it has been specially noticed that more work is thrown upon the kidneys, and the rate of expulsion of water is, compared with that in the country on limestone ground as 12 is to 5; in other words, 12 expulsions of water per 24 hours are required, while on a limestone area under similar conditions of diet only 4 or 5 are needed. The lungs also benefit greatly by the drier

air, and this is absolutely regardless of a colder temperature. It is noticed that bronchial affections rapidly disappear, and that coughs and sore throats soon vanish under the invigorating influences of a purer and drier air.

It is now known that consumption microbes multiply rapidly in moist and damp atmospheres, while dryness retards their growth.

It is to this dryness, too, that we are obliged to attribute the unusual healthiness of high latitudes, and the freedom from chest complaints of those who live on the higher reaches of the Alps and other places situate on high mountains such as Davos Platz.

We find also the greatest development of chest complaints, phthisis, &c., in damp areas, such as the West of Scotland, Isle of Man, Cumberland, and Westmorland.

It has also been noticed that the drier air stimulates the secretion of the gastric fluid in the stomach in a remarkable manner, producing at first acidity of the stomach, though this is, doubtless, temporary, and would pass away, or its effects not be felt, after a longer stay in the district.

The dryness of the air affects the body too in another way. It is found that a much smaller amount of sleep is required, nature recruiting itself much more quickly than in the town, because of the greater supply of oxygen in the air, its dryness, and the stimulation of the excretory organs.

Its effects have also been noticed on the vocal chords, which it seems to strengthen in such a way as to give the voice a firmer tone.

The acoustic properties of the air in buildings in limestone districts has also been remarked as being better than that of towns, the tones in singing being heard much more clearly; whilst the air on the surface of the limestone district is of

varied degrees of dryness, the air in the caverns is always nearly saturated with moisture, containing at least 99 per cent.

We think that enough has been said to show that these important physiological and hygienic effects are produced on the human body as the result of the peculiar geological formation underlying the soil, and that the limestone rocks are a source of important consequences to health.

Mr. SAINT proposed and Mr. JOHN ASHWORTH seconded a vote of thanks to the authors, the latter corroborating from his own experience what the authors had said as to the good effect on health of living in a limestone district.

Mr. DICKINSON: I see the greatest difference between any observations on the wet and dry bulb thermometers, according to the tables before us, is 9°. We who go down into deep mines know that, as a rule, the return air from all deep workings shows a very marked difference between the wet and the dry bulb—exceeding the highest shown in these tables. That I should suppose, from the remarks in the paper, is indicative of a healthy air. The colliers, as a rule, are exceedingly healthy and long-lived men.

Mr. HOLROYD: It is upon the greater difference on limestone areas, that we are relying—the dryness of the air being more beneficial. The greater the difference, the more beneficial is the effect it has on the body, up to a certain point.

Mr. DICKINSON: I am very glad that is made plain, because it is stated by many observers that no class of workman can earn his living to a greater age than the collier who has worked in a fairly well-ventilated mine.

Mr. HOLROYD: That is a very important corroborative proof that dryness of the air, up to a certain degree, is very

beneficial, whilst to live in an atmosphere which, on an average, is near saturation point, is more or less injurious to health.

Mr. DICKINSON: I have myself taken hundreds of observations underground, and hundreds on the surface. It is very rarely indeed that you will find the air fully saturated on the surface.

Mr. HOLROYD: With regard to the figures shown on the black board, it is true they are selected ones, but they may be taken as an average, with the exception of the last one which I quoted. This gave 11½ degrees of difference, which brought the dryness up to 48 at Castleton in the afternoon—a state of things I have never known to be equalled in Manchester and Salford during many years.

The vote of thanks was unanimously passed.

Mr. HOLROYD briefly replied and remarked that any one who wanted to learn anything about the work of underground drainage, either in its Geological, Physiological, or Hygienic aspect, could not do better than study the publications of the Societé de Spéléologie of Paris.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VIII. VOL. XXVI. SESSION 1898-99.

An ORDINARY MEETING of the Members of the Society was held on Friday, May 12th, 1899, in the Mining School, Wigan.

Mr. W. S. BARRETT in the Chair.

DEATH OF THE PRESIDENT.

The CHAIRMAN said: Gentlemen, before we begin the business of the meeting, we have a melancholy duty to perform. As you know, since our last meeting we have had the misfortune to lose our President and Treasurer, Mr. Clegg Livesey. Those who have been members of the Society for any length of time will be aware of the attention to the institution which characterised Mr. Livesey. As treasurer he occupied a position of responsibility in connection with the Society, and by electing him President the Society conferred upon him its highest honour. I will say no more with regard to a gentleman who was so well known in connection with the trade of the district, but beg to move the following resolution:—"That the Manchester

Geological Society has heard with great regret of the death of their respected president, Mr. Clegg Livesey, who also occupied for some year the posts of treasurer and trustee, and desires to express to Mrs. Livesey and family deep sympathy at their loss, and that a copy of this resolution be sent to Mrs. Livesey."

Mr. John Ridyard said: It is with sorrow that I second this proposition. I have known Mr. Clegg Livesey for many years and he was always a very useful member of our Society, particularly with regard to his long term of office as treasurer. He undertook the office of president very much against his will on account of ill health, but he was induced by the members, and particularly by Mr. Dickinson, to accept the office for the year. It is with sorrow we have heard of his death, and I quite coincide with what has been proposed by Mr. Barrett.

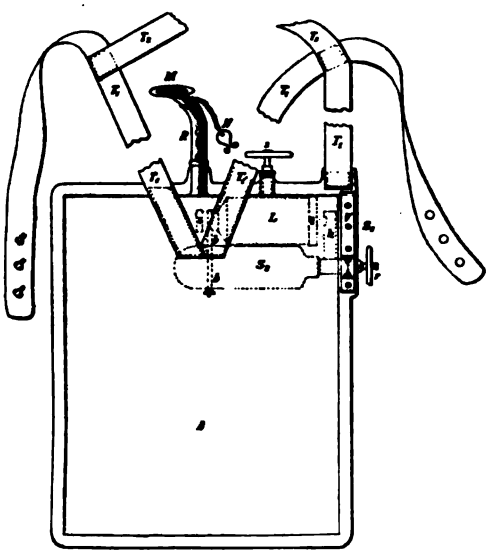
The motion was passed unanimously.

Mr. Harrison Deans exhibited and described "The Pneumatophor Rescue Appliance for use in Mines."

THE PNEUMATOPHOR RESCUE APPLIANCE FOR USE IN MINES.

By Mr. Harrison Deans.

Mr. Deans said, that after an explosion of fire damp or coal dust, or during underground fires in a mine, it was of the utmost importance that some one should go down the pit as quickly as possible to rescue anyone who



ONE CYLINDER TYPE.

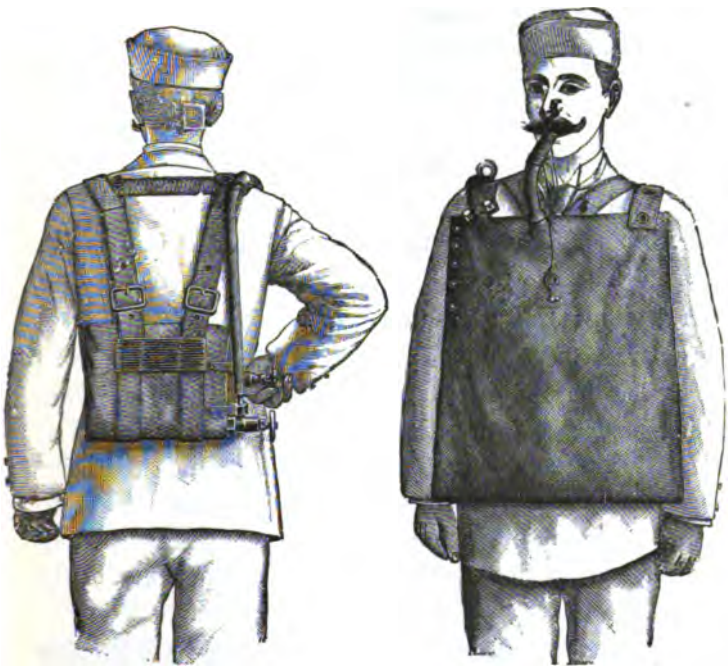
A = Breathing-bag.
M = Mouth-piece.
R = Breathing-tube.
S_1 = Slit in the bag.
$T_{1,2}$ = Straps for carrying (removable).
N = Nose-clip.
L = Caustic soda apparatus.
S_2 = Oxygen cylinder.
V = Clamp.
b = Bottle-sling.
h = Head-piece of pipe.
r = Valve-wheel.
s = Screw.

might be there alive, or if it should happen to be too late for that, to bring up the bodies of the persons who had suffered in the disaster. It was also advisable that the ventilation should be restored and the roads be opened speedily, so that the working of the mine might be resumed after the accident. It was equally well-known that it was impossible for any person to enter the after-damp without some apparatus which would enable him to breathe properly. This apparatus was extensively used in Germany at the present time. It was an Austrian patent, and when wearing it, it was possible for a man to remain in noxious gases for an hour if he did no manual labour, or three-quarters of an hour if working. They had a similar apparatus of larger size, which would enable a man to remain down three hours. The apparatus when out of use was generally kept sealed up, so that it could not be tampered with until required.

First of all there was an outer bag which was absolutely air, dust, and gas proof. In the back of it there were a couple of loofah pads for the purpose of absorbing the caustic soda solution. In the middle of the top of the bag, there was the mouth-piece; immediately upon entering an atmosphere which was bad the nose was rendered useless by the application of a nose clip, and, thereafter inhalation and exhalation were by way of the mouth only. On the right there was a steel cylinder of 0·6 litres capacity for oxygen, which was made to with-stand a pressure of 250 atmospheres. At a pressure of 100 atmospheres, it would hold 60 litres of oxygen. There was also a glass bottle containing caustic soda solution (40 per cent.) enclosed in a gauze covering.

Supposing an explosion occurred, and it was desired to go down the pit, the operator broke the seal, took the apparatus from the outer bag, and fastened it on his shoulders by the straps, so that it hung down. Then he turned a screw in

the top of the bag, which worked upon an iron plate, which in turn pressed upon the glass bottle containing the caustic soda. The bottle was then shivered, and the contents spread over the loofah pads. The wearer then went down the pit until he reached the place where there was a difficulty in breathing. Immediately he experienced that, he turned the valve of the cylinder and the oxygen escaped into the bag.



The nose clip was fixed to render the nose useless, the mouthpiece put into the mouth, and the man could then breath oxygen. Pure oxygen was inhaled at the beginning. Oxygen mixed with carbonic acid gas was exhaled and returned to the bag; the caustic soda absorbed the carbonic acid gas, thus purifying the oxygen which was used repeatedly until exhausted.

Mr. J. S. BURROWS: What would be the effect of anyone breathing pure oxygen? Would it not have a very stimulating effect?

Mr. ORSMAN said anyone breathing oxygen got very hungry. He mentioned that experiments had been made upon rabbits, with the result that they became ravenous, and could not eat enough to keep themselves alive.

Mr. J. ROBINSON: I take it that at the end of one hour there would be a foul mixture in the breathing bag?

Mr. ORSMAN: Not until the cylinder was emptied of its oxygen.

Mr. ROBINSON: What is to prevent the tube from being knocked from the mouth?

Mr. DEANS: There are two pieces of rubber into which to fasten the teeth.

Mr. TONGE: Has anyone worked with it?

Mr. DEANS: It is extensively used on the Continent. In fact it has been decreed that in certain Austrian mines coming under the fire damp section an apparatus of this kind shall be kept for use. There they made exhaustive experiments, and decreed that this apparatus should be selected. The result is that these fiery mines are fitted up with these apparatuses to the number of five per cent. of the maximum shift, including overseers and blasters.

The CHAIRMAN: There is no mechanical means of keeping the mouthpiece to the mouth?

Mr. DEANS: No. At one time a mask was tried, enveloping the whole of the face, at another a mask enveloping certain portions of the face, fitting tightly to the head, but it was found to be impracticable.

Mr. ROBINSON: I think it is important to secure the air tube so that the supply is not cut off from the man. I take it you would have no objection to demonstrating it here to-day?

Mr. DEANS: I should not, but I have not the oxygen or the caustic soda here.

Mr. Robinson: I would suggest that before it is put into use in our mines that a practical demonstration of its utility be made.

In reply to other questions, Mr. DEANS said the man wearing the apparatus carried an electric light. The weight of the apparatus was 9 lbs. Anyone with a little practice could recharge the apparatus ready for use. It could be obtained in this country from Messrs. Wallach Brothers, 57, Gracechurch Street, London, E.C.

Mr. BURROWS: There are cases in which bricksetters would be very glad to use the apparatus.

Mr. DEANS referred to the case of two men being struck down by gas in a sewer in Manchester. It was stated at the inquest that some apparatus was urgently required to enable men to go down into the sewers where the gas was present without risk to life. All sorts of apparatuses were offered, and amongst them the Pneumatophor, which was selected as the most satisfactory one to use, and it would have been adopted only for the fact that a man wearing it could not get through the man-hole into the sewer, and there were difficulties in the way of donning it after getting down.

At the request of the meeting Mr. Deans took the apparatus to pieces and explained the internal arrangements.

Mr. RIDYARD: Our thanks are due to Mr. Deans for explaining this apparatus. I feel sure that it would be useful in rescue work after an explosion, and to restore the roads in the mine. For those purposes the time required is not so very long, and the rescue party might be relieved at suitable intervals. To my mind it is well worth the attention of colliery proprietors and managers, who might at any rate give it a trial. I think some of them would be willing to

give an opportunity for testing its value. Members will remember that some years ago there was an apparatus somewhat similar to, but more elaborate than this—the Fleuss apparatus. To my mind this is superior, from the fact that it is more portable. However, it remains to be tested, and I should like to see some tests made with it. I propose a vote of thanks to Mr. Deans.

The CHAIRMAN: I second the motion. I remember when the Fleuss apparatus came out, that a series of experiments were made in the North of England, in which the late Mr. Pickard took a great interest, and I saw him use it. I think that if some means could be devised for rescue work, and could be tried without danger, the colliery interest would welcome it, and indeed anything whatever that would possibly tend to the saving of life and limb. Colliery proprietors would be very careful about having the apparatus down the pit, unless they were sure there was no danger in the use of it; and if it could be tried under similar conditions as obtain in the pit, I have no doubt it would be of benefit. Every colliery proprietor would welcome anything which tended to alleviate suffering, and save life. I have no doubt it will gratify Mr. Deans to know that the feeling of the Society is in favour of any apparatus that will carry out what this professes to do, and the colliery owners and members will be glad to witness any experiment which will convince them of its usefulness.

The motion was passed, Mr. DEANS, in replying, thanked the members for the kind way in which they had given him a hearing, and also for their friendly criticism. He mentioned that to one Austrian mine alone 275 apparatuses had been supplied.

Mr. W. J. ORSMAN gave the following address on Permitted Explosives.

ON PERMITTED EXPLOSIVES.

By Mr. W. J. Orsman, F.I.C.

On looking back at the explosions which have taken place in the Liverpool district, I find in a number of years prior to 1886 there were no fewer than 15 very serious explosions of gas from gunpowder, with a loss of 146 lives, but from 1888 to 1897 the total number of explosions caused by an explosive being fired in a coal mine in the Liverpool district only amounted to two, which resulted in six deaths, so that from 1888 the West Lancashire district had had a very remarkable immunity from accidents. About 1888, safety explosives were first introduced into this district, and if we look at the accidents which have taken place in the past ten years, not a single life has been lost from the ignition of gas or dust in a pit that can be traced to a nitrate of ammonia explosive, which is really a remarkable record.

On January 1st, 1898, the Permitted Explosives Order came into force, and the Government has sanctioned the use of certain powders—Argus Powder, Earthquake Powder, Elephant Brand Powder, and Oxalate Blasting Powder. These powders, it appears, have passed the permitted tests at Woolwich, and are sanctioned for use in certain circumstances. The question arises—How are these different from the old form of powders? In the present form the ingredients are more carefully mixed, and a large proportion of sulphur is left out. In one they mix with the powder a certain substance called oxalate of ammonia, which acts as a form of tamping. How those powders have passed Woolwich I have not the faintest conception, because experiments made in certain

places show that they are nearly as dangerous as ordinary forms of gunpowder. Under ordinary circumstances such as occur in the pit I cannot see any reason why those particular powders can be relied on as promoting safety. The addition of foreign salts to the gunpowder is made either by mixing direct with the ingredients of the powder, or as a tamping at the end of the cartridge. My argument is that any cartridge that had to have a subsidiary appliance attached to it is a bad one for the pit, for supposing the tamping was removed altogether, the powder would act like ordinary blasting powder, and might produce an explosion. Then again, coal dust is very sensitive to all forms of gunpowder, and if one of those cartridges got ignited in the pit, and there happened to be any coal dust around, immediately the whole of that coal dust would burn, and initiate a very disastrous accident. It is not necessary to have gas in the pit to cause explosions; all that is wanted is to have a layer of dust, and incautious shot-firing. I think in the near future those permitted gunpowders will be excluded altogether, or very stringent rules laid down for their use. I think it necessary to place in the hands of the collier an explosive which will be perfectly safe when subjected to rough treatment—an explosive which should be incapable of being ignited by friction, accidental hitting with the pick, or a blow of a hammer.

With regard to the question of firing the cartridges, I find that the practice is, when two cartridges are fired together, to put the detonator at the end nearest the back of the hole, or when three cartridges are used, to put the detonator in the middle cartridge. That method is absolutely wrong, and has nothing to recommend it, and might be a source of danger. The detonator should always be placed at the extreme end, and at the end nearest the bore-hole. This latter position is

necessary for the following reasons. If a cartridge, or part of a cartridge, fail to explode, the impact of explosion at the front will simply crush the unexploded part into a solid block at the back of the hole, where it can easily be found and recovered. If, however, the detonator is at the back of the hole, any unexploded portion will be sent flying in all directions with the coal, and so will easily escape detection. Further, if the coal is not brought down, and a blown-out shot produced, then any unexploded portions will be projected over the surface of the coal at the sides of the bore-hole with an enormous velocity, and the friction set up may cause the explosive to ignite, and so set the coal on fire. With the detonator nearest the mouth of the bore-hole, such a circumstance is impossible. Investigation of a large number of cases where difficulties have arisen has shown that such have been almost invariably due to wrong methods in charging the shot-hole.

Mr. Saint said he had much pleasure in proposing a vote of thanks to Mr. Orsman for his interesting observations on Permitted Explosives, and especially for his practical information with regard to shot-firing generally. Probably Mr. Orsman was aware why the men placed the detonator in the cartridge at the back of the hole, the wires being carried along the side. His impression was that the shot-firer put the detonator there in order that it might not be separated from the charge during stemming, and that while tamping he might have less risk in exploding the detonator by percussion. He thought that was the idea that prevailed amongst the miners. With regard to the experiments at Woolwich, the test of firing with a cannon did not appear to be on a parity with practical operations in the mine, because at the back of a shot-hole they sometimes had a fissure from which a feeder of gas escaped, and it was easy to imagine that in blasting

under such conditions, there would be great risk of firing such feeders.

Mr. BURROWS, in seconding the motion, said, from 1869 all the explosions in Lancashire were in the Wigan Nine Feet Mine, whereas before that they were in the Arley Mine. There was a certain run of those explosions, they began at Haydock and went through to Tyldesley, in the same seam though with different local names. He wondered whether there was any different gas given off in that mine, or whether there was something particular in the nature of the dust, because it was a most singular fact that there should be explosions in the same mine for several years, occasionally twice in one year.

Mr. ORSMAN: I believe I am right in saying that in the Nine Feet Mine they hole at the top and put the cartridge at the bottom, and there have been more accidents in the Nine Feet Mine than in all the other mines of Lancashire put together, for the simple reason that the shot has blown into layers of dust. They have not been actual gas explosions, but ignitions of dust on the floor.

Mr. BURROWS: I am very glad I asked the question. Now it is pointed out, it stands to reason that if there is a blown out shot near the floor, there is the dust at hand to cause an explosion.

The CHAIRMAN: I remember very well that the Wigan Nine-feet used to be the most dreaded mine, but I think that then coal dust was not recognised as a factor in explosions, and it is possible that Mr. Orsman's theory may be a very good one.

Mr. MATTHEWS: It would be a good plan for every colliery manager to try for himself certain experiments, before he decided to use the so-called safety powders.

The motion was passed, and Mr. Orsman briefly responded.

This concluded the business of the Meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IX. VOL. XXVI. SESSION 1898-99.

The ORDINARY MEETING of the Members was held on Tuesday, June 13th, 1899, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. MARK STIRRUP, F.G.S., in the Chair.

THE LATE M. CHARLES BRONGNIART.

The CHAIRMAN said: Before I call upon Mr. Lomax for his paper, I wish to call the attention of the members to the death, which took place recently, of one of our Honorary Members, M. Charles Brongniart, whose work on Fossil Insects I have from time to time brought before this Society. He was a young man of brilliant intellect, and bore a name which was honoured in the ranks of science, not in his own country only, but throughout the world. He belonged to a family which has been distinguished in various scientific walks for several generations. His great grandfather, Alexandre Brongniart, was associated with Cuvier in the preparation of his treatise on the Geology of the Environs of Paris, and his grandfather was the celebrated Adolphe Brongniart, who was really the first to investigate, and give to the world, a scientific classification of fossil plants.

Charles Brongniart for many years applied himself especially to entomology. In the Coal Measures of Central France, at Commentry, fossil insects occurred in singular profusion and variety, and to these he devoted, I may say, his life's work. His labours resulted in the publication of two richly illustrated volumes, copies of which he presented to this Society. In the last letter I had from him, which was after the publication of this work, he complained of the injury done to his eyes by the strain arising from close application to the microscopical part of this work, and I fear he is to be regarded as another martyr to the cause of science, for the application requisite to arrive at the wonderful results of delineation of minute structures which he attained, must have been severe. I presume it will probably be the wish of the members of this Society that a letter of condolence should be sent to his widow, with a statement of our sense of the loss sustained, not only by this Society (to which he has contributed several papers), but the whole scientific world, by his death. I move that such a letter be sent.

Mr. Dickinson seconded the motion, which was unanimously approved.

The Chairman also announced that the third volume of Hutton's "Theory of the Earth" just published under the able editorship of Sir Archibald Geikie, had been presented by Mr. Whitaker, the President of the Geological Society of London, an Honorary Member of this Society, who had, at various times, made many valuable gifts to the Library.

FINE SLICKENSIDES IN CANNEL.

Mr. Henry Hall exhibited a specimen of Cannel from the Wigan Four-feet at Abram (there about 6 ft. 6 in. thick), presenting a highly polished surface. The cannel showed these bright plane surfaces, equal, or superior to any artificial polishing, wherever there were vertical breaks. These breaks or slips extended from the top of the seam to the bottom, and both sides were polished. In one instance he saw a fine example six feet square.

POSSIBLE CASE OF INVERSION OF A FOSSIL TREE.

Mr. Henry Hall also brought before the notice of the meeting a case of what he supposed to be a fossil tree upside down. He said: This tree is resting on the top of the Haigh Yard Mine in one of Messrs. Pearson & Knowles' Collieries. It is about 2 ft. 10 in. in length, about that diameter at the upper extremity, and only about 15 in. at the lower end. It is covered by about one-third of an inch of pure coal all round.

The gentleman who sends me the information, Mr. G. H. Howarth, says in his letter; "I inform you of this, because it is the first in my experience which has been met with upside down, and if my statement of its present position is correct, it is a powerful argument against the *in situ* theory." I have looked at the tree myself, and I think this description of it is perfectly correct. The roots do not appear to be noticeable.

Mr. G. WILD: I should be inclined to doubt its being upside down, unless the roots were clearly to be seen. It is possible the bottom end of the trunk may have decayed rather more rapidly than the upper portion, and have been squeezed in, previous to the filling in of the upper portion. It is no proof of its being upside down because the lower part of the tree is of less diameter than the upper.

The CHAIRMAN, referring to a sketch accompanying Mr. Howarth's letter, said he could discover no appearance of roots. If gentlemen desired to visit this colliery they should go at once, because in a case of this kind alterations in the workings might take place rapidly.

Prof. F. E. WEISS said: It requires to be proved, first that it is a stem; and secondly, that it is inverted. If the scars are preserved we could tell whether it is inverted; but if they are not, it may, with equal probability, be a root, and as such would only be tapering in the natural direction. It seems to me that in the absence of sufficient evidence the matter must be left in suspense.

Mr. JAMES LOMAX then read a paper on "Recent Investigations on Plants of the Coal Measures."

RECENT INVESTIGATIONS ON PLANTS OF THE COAL MEASURES.

By Mr. James Lomax.

Illustrated by Specimens, Sections and Photographs.

It is my intention in this paper to describe to you a few plants of the Coal Measures with which I have had a great deal to do, having made hundreds of sections. When I commenced palæ-botanical work some twelve years ago, the descriptions of these were in a very disorganized state, some three or four parts of the same plant having different generic names, but happily during the last few years we have been able to clear a good deal of this away.

Lyginodendron.

The two genera *Lyginodendron* and *Heterangium* are among the most interesting, and at the same time the most puzzling representatives of the Carboniferous flora, yet the structure of all their vegetative parts is preserved with such completeness and perfection, as to enable us to show that these fossils present a combination of characters such as exists in no group of plants now living; unfortunately we have not been able, so far, to find their reproductive organs, and can only weigh with great care such evidence as is afforded by their vegetative structure.

This evidence clearly shows, so far as it goes, a position intermediate between ferns and cycads.

On February 20th, 1866, the late Mr. Binney gave to the Literary and Philosophical Society of Manchester a brief description of a new plant from the Lower Carboniferous beds of the neighbourhood of Oldham. The following extracts briefly describe the nature of the plant:—

"It evidently belonged to the genus *Pinites* of Witham, since changed by Endlicher and Brongniart into *Dadoxylon*."

It "had a medullary axis composed of irregular polygonal cells separated by intervening spaces vertically, and thus forming a kind of discoid pith." "This is separated by lunette-shaped bundles of hexagonal tubes arranged in a convex form from the pith inwards, and lessening in size as they pass outwards into wedge-shaped masses of four-sided sub-hexagonal cellules, arranged into radiating series, and divided by large medullary rays or bundles, which appear to originate in the lunette-shaped masses. On the outside of this internal radiating cylinder are other lunette-shaped bundles similar to those in the inside." "Then comes a narrow zone of lax tissue, which has been a good deal disarranged. Outside this are some thin wedge-shaped bundles of cellules, full of dark carbonaceous matter, and arranged in radiating series of varying sizes, separated by lax tissue, probably representing the bark of a tree."

To the plant thus described Mr. Binney gave the name of *Dadoxylon Oldhamium*. It stood thus till the year 1869, when the late Prof. Williamson in a brief Memoir published in the *Monthly Microscopical Journal*, pointed out that since the appearance of the Memoir on *Dadoxylon*, that numerous specimens of woody stems had been found, transverse sections of which exhibited a structure identical with that of living conifers; but longitudinal sections showed that the vessels or fibres were altogether different from the coniferous type. Instead of bearing rows of discs, and those only on the surfaces of the vessels parallel with the medullary rays, their entire wall was covered with reticulations formed by the deposition of lignine in the interior of the vessels. Then, after describing some figures, he went on to say, that "whether these prove to be different species of one genus, or whether they will require more than one genus for their reception, remains to be seen. But certainly none of them can be regarded as *Dadoxylons*, since they belong to an altogether different type of structure."

"It appears necessary, therefore, to establish a new genus for all plants whose woody cylinders consist of reticulated vessels and fibres, and the name *Dictyoxylon* appears an appropriate one for it, and I should propose for the present to include in this genus all the reticulated types, whether their medulla consist of one or of several vertical series of cells. At some future time their further separation into two or more genera may be requisite."

At the Edinburgh Meeting of the British Association in 1871, Professor Williamson described yet more definitely his genus *Dictyoxylon*, especially as represented by three plants, viz., Mr. Binney's *Dadoxylon Oldhamium*, a new species from Burntisland to which he give the name of *Dictyoxylon Grievii*, and a third from the Lancashire Coal Measures, to which he gave the name of *Dictyoxylon radicans*. But further investigations into the nature of the latter plant led him to separate it from *Dictyoxylon*, and give it the generic name of *Amyelon*. I may add here that this so far has not been changed, although it is supposed to be the roots of *Sphenophyllum*, though there is as yet no actual proof. At this time Professor Williamson, you will observe, did not think that any plants possessed reticulated fibres besides his genus *Dictyoxylon*, hence his mistake in the generic name.

We now come to the end of 1872, when Professor Williamson gave his fourth Memoir to the Royal Society* on *Dictyoxylon*, *Lyginodendron* and *Heterangium*. It seems in the meantime that three or four Oldham men had been collecting specimens which they put into the hands of Professor Williamson, by which he was able to do more than he had previously been, to identify the different vegetative structures; also he had become acquainted with the figure of a sandstone fossil described by Mr. Gourlie, exactly like the outside of the *Dictyoxylon Oldhamium*, and with a figure in

* Phil. Trans. Roy. Soc., 1873, p. 377.

Corda's "Flora der Vorwelt" of a plant from the Bohemian Coal Measures, to which Corda gave the name of *Heterangium paradoxum*. Mr. Gourlie had given his fossil the name of *Lyginodendron Landsburghii*, after the Rev. D. Landsborough, the finder of the fossil. Williamson at this stage says there is no room for doubting that the *Lyginodendron* of Gourlie is a sandstone impression of the bark of *Dictyoxylon Oldhamium*, consequently as Mr. Gourlie's specimen is the older he must change the mame of *Dictyoxylon Oldhamium* to that of *Lyginodendron Oldhamium*.

Also the same with *Dictyoxylon Grievii*. He must call it *Heterangium Grievii*, as Corda's figure was the oldest.*

By acting thus he not only created no new genus, but by the extinction of his new term *Dictyoxylon* actually reduced the existing number.

In the conclusion of his memoir, he notices specimens of what he then named *Edroxylon*, but which he changed afterwards to that of *Rachiopteris aspera*.

At this stage it was left till the year 1890, when Prof. Williamson published. his Memoir No. 17, (in the Phil. Trans. Roy. Soc.) on *Rachiopteris aspera* and *Lyginodendron*, but in the meantime he and others had collected a great quantity of material together. I had the honour of supplying him with sections and specimens, clearly proving the connection of *Rachiopteris aspera* with *Lyginodendron*, and also of leaves attached to the *Rachiopteris aspera*.

He states that the above facts combined make it clear that *Rachiopteris aspera* is merely a petiole or branch of *Lyginodendron Oldhamium*, hence the former name must disappear from our lists. It also follows that *Lyginodendron Oldhamium* is a true fern, most probably of the *Sphenopteris* type. This determination carries along with it the further one, that the stems of some, at least, of the ferns of the

* Phil. Trans. Roy. Soc., IV., 1872, 404.

Carboniferous age, developed their xylem or vascular zone exogenously through the instrumentality of a meristemic zone of the innermost cortex, which practically must be regarded as a cambium layer. But the history of this plant is not yet ended.

He also says: "In various preceding memoirs, but notably in Part XVI., I have provoked a strong opposition amongst some botanists whose studies have been chiefly limited to living forms of vegetation, by revealing the existence amongst the Lycopodiaceous plants of the Coal Measures of a mode of development of a medulla which differs so widely from what occurs amongst living plants that the sceptics are unable to accept my account of it." He said, with his late friend, Prof. Du-Bary, that in scientific investigation nothing was impossible.*

The history of our knowledge of the leaves of *Lyginodendron Oldhamium* is briefly as follows:—

In the Proceedings of the Royal Society, Memoir IV., (xx. 438) 1872, Williamson says: "I have pointed out the existence in the Lancashire nodules of abundance of small stems or petioles, to which I gave the provisional name of *Edroxylon*. I have since succeeded in connecting these petioles with the leaflets of *Pecopteris*. I think it far from impossible that these may prove to belong to *Dictyoxylon Oldhamium*; but since I have not yet succeeded in correlating them with any certainty, I shall add no more respecting them at present."

In Memoir VI., 1874, Proc. Royal Society, Prof. Williamson fully describes the above specimen, and gives it the generic name of *Rachiopteris aspera*. (See plate I, phot. 4.)

In the latter end of 1889 I found two or three specimens amongst the material from Dulesgate, which clearly proved that *Rachiopteris aspera* was the petiole of *Lyginodendron Oldhamium*, and which Prof. Williamson made use of in Memoir XVII., 1890. (See phot. 10, plate II.)

* Phil. Trans. Roy. Soc., XVII., 1890, 91.

At a later period I found additional specimens in a much better state of preservation, also from Dulesgate, and which are figured in the Phil. Trans. Roy. Soc., Williamson & Scott, Part III., 1896, Photographs 3, 8A, and Figure 10, Plates 18, 19, and 23. Phot 10 on plate II. is from the same series of sections as those here named.

In all the sections figured the petioles are in continuity with the stem, and, at the same time, they present the characteristic structure of *Rachiopteris aspera*.

Other sections show the same petiole after it has become free. Figure 11 thus shows the upper part of the same petiole in longitudinal section at a point where it is beginning to branch.

All the above mentioned sections show also the cortical emergences or leaves, thus affording direct proof that *Rachiopteris aspera*, the only *Rachiopteris* that possesses these outgrowths, was the petiole of *Lyginodendron*.

The stems of *Lyginodendron* are almost invariably found to be surrrounded by a multitude of fragments of foliage, among which petioles of all sizes, often in the act of branching, are to be recognized, as well as portions of leaflets.

I have had sections of *Lyginodendron* with *Rachiopteris aspera*, and attached to the *Rachiopteris* were to be seen most clearly the finer petioles with the leaflets in a perfect state of preservation, which prove, at all events to me, that the foliage is that of *Sphenopteris Hæninghausi* (Brong.)

The mere fact that the foliage of *Lyginodendron* resembled that of ferns is not in itself a proof of their affinity with them.

But we must also remember that we have in *Lyginodendron* not only fern-like form and venation in the foliage, but also fern-like structure in the petiole.

Two series of sections that clearly prove the above are in the possession of Dr. D. H. Scott and Count Solms-Laubach, from material which was found in the beginning of 1898.

In the Philosophical Transactions of the Royal Society, 1876, Memoir VII., Prof. Williamson describes what he calls one of the most remarkable, as well as the most beautiful, of all the fossil plants that he has met with in the Lancashire deposits. He states in his Memoir "that the plant is a Cryptogam, there can, I think, be no doubt. All its vessels are the mere modifications of the spiral and the barred tissues which constitute so universal a feature in the stems of the other Carboniferous Cryptogams. It possesses this feature in common with the *Calamites*, *Lepidodendron*, *Astrophyllites*, and other Carboniferous Cryptogams which I have already described."

He also says that in one respect "the plant under consideration is one of the most remarkable of any plant that I have yet seen, as the largest stem that I have found does not exceed one eighth of an inch in diameter, yet its exogenous development is complete, and since the plant now described is remarkably distinct from any other hitherto noticed, I propose to assign to it the generic title of *Kaloxylon*, and to indentify it with the name of our distinguished President as *Kaloxylon Hookeri*." (See phot. 5 and 6, plate I., and 9 and 11, plate II.) I found, among the sections that I prepared from the Dulesgate material for Prof. Williamson, in 1889 and 1890, there were scattered amongst the tissues of the *Lyginodendron* numerous small stems, transverse and otherwise, of *Kaloxylon Hookeri* clearly in connection with the stem; and even in Memoir IV., 1872, Professor Williamson figures appendages emerging from the stem of what he at that time called *Dictyoxylon Oldhamium*, but now *Lyginodendron Oldhamium*. The appendages in question are shown passing through and out, more or less horizontally from the wood and traversing the cortex. He at that time regarded them as branches. But since 1890, I have had a great number of

sections showing these organs in connection with the stem, and in a very fine state of preservation.

In the Proc. Roy. Soc., 1896, Memoir III., of Williamson and Scott, some of these are figured, and this is what they state :—

First, that the appendages in question were of exogenous origin, and presented in all respects the characteristic structure of roots.

Second, that these roots are identical with the fossil previously known as *Kaloxylon Hookeri*. Then they go on to prove that morphologically the appendages are roots.

"Adventitious roots, with the rarest exceptions, are of endogenous origin; they arise from deep-seated tissues (pericycle or endodermis), and have to grow out through the cortex of the parent stem, and hence they are readily distinguished from stem-branches which are almost of exogenous origin, arising from superficial tissues. A section of the cortex of the parent stem, passing through the base of an adventitious root, will show the latter as a complete organ, possibly a cortex, and an epidermis of its own; a corresponding section at the base of a branch would show only the vascular tissues which connect the bundles of the branch with those of the stem." (*Page 733.*)

The largest stems of *Lyginodendron Oldhamium* that I have seen do not exceed more than 2¼ inches in diameter, though Prof. Williamson had a decorticated specimen which he called the Neild specimen, now in the possession of the British Museum, and which Mr. A. C. Seward described in the Annals of Botany for March, 1897, under the name of *Lyginodendron robustum*.

Prof. Williamson describes it as follows in Memoir IV., Proc. Roy. Soc., 1872, "I have obtained from Mr. Neild one magnificent axis, in which the woody cylinder and its contained medulla has been at least 18in. in circumference; the thickness of the wall of the vascular cylinder has been

at least 2½in., and since the specimen is weathered and waterworn it may have been of even larger dimensions." In a foot-note the specimen is said to have been found in a watercourse intersecting the Lower Coal Measures at a locality known as Har Culvert, near Oldham.

Unfortunately the only structure preserved is that of the secondary wood; its general anatomy is identical with that of certain specimens of *Lyginodendron*, but not conclusive, and I should say that till some other fossil has been found which agrees better with this doubtful stem we might assume that it either belonged to a *Lyginodendron*, or to some plant of the same type of structure. Thus Mr. Neild's specimen affords a certain amount of evidence that *Lyginodendron Oldhamium*, or some allied species, may have attained the dimensions of a small tree.

As regards the habit of the ordinary specimens with which we are familiar, the radial symmetry of the stem, and the fact that adventitious roots, when present, are given off on all sides, render it probable that the plant grew in an upright position.

The longest piece of stem that I have had was 10 inches long, and in that length it had given off three petioles (*Rachiopteris aspera.*)

Williamson and Scott, in conclusion, (Mem. III. Phil. Trans. Roy. Soc., 1896, p. 743,) on the habits and dimensions of *Lyginodendron*, say "from the course of the vascular bundles we know that the total length of the stem must have included many internodes, for, if our interpretation of the facts be correct it follows that each transverse section of the stem usually shows the traces of the next ten leaves above. We must therefore picture *Lyginodendron* to ourselves as having a tall upright stem rising to the height of several feet and bearing somewhat remote, spirally arranged, highly compound fern-like leaves.

"The base of the stem, where the adventitious roots were given off must have been buried for some depth in the earth or mud. Probably the bases of the stems would be the parts most often preserved, which would explain the frequency with which adventitious roots are met with in connection with the stem. It is not probable that the roots were aërial; the fact that they branched freely, immediately on leaving the stem, militates against such an idea.

"The velamen-like outer layer, which might suggest an aërial root, is common to the finest rootlets, and these must almost certainly have been subterranean. The well-developed xylem of the roots renders it probable that they vegetated in a fairly firm soil."

Whether Williamson and Scott are right in the statement, I question, as I have had many sections where a petiole has been given off, and immediately above and underneath it have been rootlets; and I lean to the belief that the rootlets were aërial in some cases, if not in all.

Then on the other hand, the stems, I think, could not have been underground rhizomes; they are well constructed mechanically, and thus fitted to maintain an upright position while bearing abundant foliage. Also, the small specimens which constitute almost the whole of our material could not have been branches borne on main stems, for in that case they would not have borne adventitious roots. If the plant attained a relatively large size, then we must assume that our material is made up of young specimens.

It is not often that we come across a cast of *Lyginodendron*, but in the cases where we do find them, the markings have been similar to those of the finely meshed *Lepidodendra*, and the probability is that if the plant attained a very large size, some of the Lepidodendroid casts would represent the outside of *Lyginodendron*.

This now brings us to the fructification. It is a remarkable fact that we have never yet seen any signs of the fruit, though it is one of the commonest of our English coal fossils; and though all its vegetative organs are preserved with astonishing perfection, no certain traces of reproductive organs have ever been discovered. Fern sporangia are often found among the fragments of *Lyginodendron* foliage, but never in actual continuity with it. Two possibilities suggest themselves. First, *Lyginodendron* may have been a true fern as to its fructification, and bore sporangia on its leaves; they might very easily have become detached. Secondly, it is possible that our material consists of young plants, in which case the absence of fructification is easily accounted for.

There is another genus of plants which is most probably allied to *Lyginodendron Oldhamium*, and that is the genus *Heterangium*, which was founded by Corda in 1845, on a fragmentary specimen from the Bohemian Coal Measures.

The first British specimens were discovered in 1871 among Mr. Grieve's Burntisland fossils. This form was originally named *Dictyoxylon Grievii*, but in 1872 was placed in Corda's genus, and now bears the name of *Heterangium Grievii*, Will.

In 1889, I discovered in the Dulesgate material two forms of *Heterangium*, one figured by Williamson in Memoir XVII., 1890, and the other by Williamson & Scott, Part III., 1896. (Proc. Roy. Soc.) The first one Williamson figures as *Heterangium Grievii*, and the other as of an uncertain species.*

But in 1886 there had been a second species found at Halifax, which Williamson figured in Memoir XIII., 1887, and described as *Heterangium tiliæoides*.

* Phil. Trans. Roy. Soc., 1896, fig. 21, plate 26.

I think it unneccessary to go into any detailed description of the structure of this genus, but just point out the affinities of the two genera of *Lyginodendron* and *Heterangium*.

Heterangium has to a very great extent a strong resemblance to *Lyginodendron*, and both of them strongly resemble ferns. As to the latter genus it is proved beyond doubt that the highly compound leaves were those of a *Sphenopteris*, and in *Heterangium* the general character of the foliage was evidently similar.

The external form and the venation of the leaf would by themselves carry no decisive weight, though hundreds of fossil species have been referred to the ferns on no better grounds. But beyond this the structure of the leaf is now well known in *Lyginodendron*, and to a less degree in *Heterangium*, and proves to be in all respects that of a fern, as is shown most clearly by the concentric structure of the vascular bundles in the petiole and rachis.

This holds good for both genera, both in structure and form, so the leaves of *Lyginodendron* and *Heterangium* are fern leaves; their one point of difference being the occurrence of pitted as distinguished from scalariform tracheïdes in their xylem.

So far we have considered only the points in which our two genera approach the ferns. I have now to call attention to the remarkable relation which their structure shows to that of cycads.

The secondary tissues strongly resemble those of cycads; the resemblance shows itself in the simple structure of the secondary wood, the great number of the medullary rays, and tracheïdes with bordered pits on their radial walls.

The structure of the phloem also agrees well with that of cycads, and in the case of *Heterangium tiliæoides* the agreement extends to the details of the sieve plates.

Williamson & Scott, Mem. III., 1896, say: "So far as the secondary tissues are concerned, the cycadian characters apply to both *Heterangium* and *Lyginodendron*, though on the whole more marked in the latter. The primary structure of the stele in *Heterangium* bears no resemblance to that of a cycad, while in *Lyginodendron* the presence of a pith and distinct bundles create a certain similarity.

"The most interesting and remarkable point is that the vascular bundles in the stems of *Lyginodendron* have exactly the same structure as those in the leaf of existing cycads. This applies also to the leaf traces and the bundles which form the outer part of the stele of *Heterangium*."

We have seen by the above that *Lyginodendron* verges on the borderland between ferns and cycads, but how far it may go on the one side or the other cannot be fully determined till we have sure proof of the fructification.

The view that Williamson and Scott take (1896) is that they are the derivatives of an ancient and "generalized" (or rather non-specialized) stock, which already shows a marked divergence in the cycadian direction. Of the two genera, *Heterangium* appears to be the more ancient, and certainly stands nearer to the ferns; *Lyginodendron*, while retaining fern-like structures, has advanced much further on cycadian lines.

They believe that in *Lyginodendron* and *Heterangium* we have fern-like plants of a primitive type, which have undergone modifications of the same kind as those to which the cycads owe their origin.

MEDULLOSA.

I have now to describe our latest (with the exception of the *Lepidodendron* referred to at the end of this paper) discovery in Palæobotany, which bears out to a certain extent

the above cross between ferns and cycads. *(See Plates III., IV., and V.)*

On January 26th of this year, Dr. Scott, Keeper of the Jodrell Laboratory, Royal Gardens, Kew, described a new *Medullosa* (*M. anglica*) that was found by Mr. G. Wild and myself at the Hough Hill Colliery, Stalybridge. No. 1 specimen was found in 1892, Nos. 2, 3, and 4 in 1898.

On the Continent certain fossil plants have been described under the generic name of *Medullosa*, some of which have been of a very large size, up to 20 inches or more in diameter, and of a very complex structure, containing a system of numerous vascular rings of the most various dimensions and shapes, each ring growing in thickness by a cambium layer of its own.

At first sight the structure bears a great resemblance to that of the Sapindaceæ, to which it was compared by Göppert and Stenzel. But more recent writers, as Zeiller and Count Solms-Laubach, say that the general characters of the secondary tissues, and the anomalies presented by certain of the older stems, are strongly suggestive of the Cycadaceæ, though the ground plan is that of the Ferns.

The investigations of Schenk, Solms-Laubach, and Weber and Stenzel have left no doubt that these extraordinary stems bore as their petioles the fossils known under the generic name of *Myeloxylon* (Brong.). The leaf-stalks, which are often of a very large size, have essentially the structure of Cycads, but Renault has shown the foliage to be that of *Alethopteris* and *Neuropteris*, the external characters of which are entirely fern-like.*

In the latter part of the year 1892 I found, when cutting up some material collected by Mr. G. Wild and myself at the Hough Hill Colliery, Staleybridge, a large stem of what we at the time thought to be a crushed and broken

* Phil. Trans. Roy. Soc., Scott, Mem. III., 1899, page 82.

Heterangium. I made a rough section of it and sent it to the late Prof. Williamson, who evidently thought the same, as, after his death it came into the possession of Dr. D. H. Scott, labelled in Prof. Williamson's own handwriting, "Very large *Heterangium* and crushed *Myelopteris*." (*See Fig. 2, Pl. 5, Mem. III., Dr. D. H. Scott, Phil. Trans. Roy. Soc., 1899.*) Until 1897 I had this specimen in my cabinet, but at the latter end of that year I commenced to cut it up, and sent some of the sections to Dr. Scott. He immediately saw the importance of them, so that I cut it up into a great number of sections (considerably over a hundred), in various directions, such as seemed best to show the various structures. These have been examined by Dr. Scott.

He had practically completed his investigations on this specimen, when, in June, 1898, I discovered two more specimens in some material collected by Mr. G. Wild some time previously from the same colliery.

A portion of one of these fine specimens is represented in its external aspect in Phot. 14, Pl. 6, and transversely in Photo. 8, Pl. 4. Since that time we have found two or three other specimens from the same locality.

The above specimens are of very great interest, not only as being the first recorded British specimens of the genus *Medullosa*, but also from their geological horizon, which is more ancient than that of those recorded from the Continent, which have always been found in the Permian and the Upper Coal Measures, while ours, like the other coal plant specimens showing structure, have been found in the Upper Foot or Gannister Mines of the Lower Coal Measures.

Dr. Scott says that the structure of the specimens represents a true *Medullosa*, differing in certain important respects, chiefly in the direction of greater simplicity of

structure, from any species previously described; and that it is necessary to distinguish the British form by a specific name. He therefore names it *Medullosa anglica*. (*See Phil. Trans. Roy. Soc., Scott, Mem. III., 1899.*)

The following is from Dr. Scott's description, which he has placed at my disposal, of the new plant, in the Abstract of the Proceedings of the Royal Society:—

"*Medullosa anglica*, in the structure of its stem, shows unmistakable affinities with *Heterangium*, perhaps the most fern-like of the genera grouped under Cycadofilices. The new species is far simpler than any *Medullosa* hitherto described, for the steles are not only few but are uniform, showing no differentiation into a peripheral and a central system. The small central steles, called 'Star-rings' in other Medulloseæ, are absent here. In these and other points the species agrees with the genus *Colpoxylon* of Brongniart, but as that genus is doubtfully distinct and its leaves are not known, it is not proposed to unite the English species with it.

"In the structure of the petiole and of the leaf generally, *Medullosa anglica* is as highly organised as any of the Medulloseæ, and agrees closely with *M. Leuckarti*, the only other species in which the connection between leaf and stem has been at all satisfactorily proved.

"In the structure of the petioles, and of the roots, in the secondary tissues, and in the secretory canals, which occur throughout the plant, there are clear points of agreement with Cycads, though the primary structure of the stem was that of a Fern. The affinities in the latter direction come out more clearly in *Medullosa anglica* than in any of the other species at present known.

"The habit of the leaves, if as appears likely, they were of the *Alethopteris* type, must have been fern-like, but that in itself, as the familiar example of *Stangeria* teaches, is as consistent with Cycadaceous as with Filicinean affinities.

"While *Medullosa* thus combines, in a striking manner, the characters of Ferns and Cycads, I am not disposed to regard it as having lain very near the direct line of descent of the latter group. It is more probable, as Count Solms-Laubach has suggested, that the Medulloseæ represent a divergent branch, which has left no descendants among existing vegetation."

We have in the above three types of fossil plants a most interesting study, wherein we get both the fern-like and Cycadian structure of tissues in one plant; and in the case of *Medullosa anglica* the organisation has been worked out with more success than in any of the previous plants, both as far as the stem, leaf-stalks, leaves (which are *Alethopteris*) and the roots, without getting three or four names for portions of one plant. "The convenient name, Cycadofilices, has recently been proposed by Professor Potonié to designate the group in question, which now includes several, somewhat heterogeneous, genera, which include *Lyginodendron*, *Heterangium*, and *Medullosa*."

Calamites and Roots of Calamites.

Williamson and Scott in their joint Memoir I., 1895, state that when they began writing that paper they did not expect to be able to throw any light on the structure of the roots of *Calamites*. Specimens showing the roots in connection with the stem, and having at the same time the internal structure preserved, were not yet known to them.

Consequently it was impossible to determine which, if any, of the petrified remains were to be assigned, as roots, to the Calamitean stems. But Dr. D. H. Scott, had the opportunity of examining certain specimens in the collection of M. Renault, which placed the question in quite a different light.

Two of those showed an axis, with the structure of *Astromyelon*, in actual continuity with the stem of an Arthropitoid Calamite, identical with such as they had described in their paper.

M. Renault expressed the opinion in 1885 that *Astromyelon* was the root of *Calamites*, and it was confirmed by specimens found after that date in French material. In September, 1897, I found a specimen of a Calamite about four inches long, with the roots, which are clearly *Astromyelon, in situ* at two different nodes. These sections are now in the possession of Dr. Scott. Since that time I have found three other examples, one of which is in the possession of Count Solms-Laubach, of Strasburg, another is at University College, London, and the third I have still in my possession.* It is interesting to note that *Astromyelon* was first figured as a Calamite, but subsequently removed on the ground of certain structural differences, which find a sufficient explanation if the organs in question are to be regarded as roots and not stems. Some of the later examples, especially the one in the possession of Count Solms-Laubach, have smaller rootlets branching from the *Astromyelon*, which have been figured by Messrs. Hick and Cash, as a genus *Myriophylloides*, but which is really an *Astromyelon* with the outer cortex intact.

I have said sufficient here to record the fact of *Astromyelon* being the root of *Calamites*. But we have also to consider the fruit of *Calamites*, which has not been found in actual continuity except in the one specimen found by myself and Mr. J. Earnshaw, of Oldham, figured by Williamson as the true fruit of *Calamites*. It is assumed by most paleobotanists that *Calamostachys* is the fruit of one of the *Calamites*, but there is no conclusive proof of this being the case. I myself believe that we have a great variety of

* This has since been divided between Prof. Weiss and Mr. R. Kidston.

species of *Calamites*, and that it is possible that *Calamostachys Binneyana* may belong to one of them, or to some totally different plant altogether.

I have yet one other discovery to record. In July, 1898, I was fortunate enough to come across a magnificent specimen of a Halonial-like stem of a *Lepidodendron*, from material collected at Hough Hill, Stalybridge, by my friend, Mr. G. Wild. It is the finest specimen of a *Lepidodendron* showing vegetative structure that has yet been found in the English Coal Measures. It is no doubt allied to some of the recognized types of *Lepidodendron*, probably it is the fructification branch of *Lepidodendron fuliginosum* of Williamson. I have given it into the hands of Prof. Weiss, of Owens College, to describe, which no doubt he will do shortly. (*See Plate V., Phot. 22, and Plate VI.*)

Mr. SAINT: I have much pleasure in moving a vote of thanks to Mr. Lomax for his excellent paper. In the work of section-cutting he has had large experience; he did a good deal of it for the late Professor Williamson; and we must give him credit for the application he has given to the work for many years, which is so admirably represented by the beautiful specimens exhibited before us to-day.

Mr. S. S. PLATT: I have great pleasure in seconding the vote of thanks to Mr. Lomax; I have a personal knowledge of Mr. Lomax's work in this direction, in fact it was through him I commenced the study, to a small extent, of palæo-botany. Mr. Lomax has devoted much time and patience to this work, and the late Professor Williamson was largely indebted to him for many of the specimens and novelties described in his memoirs.

The vote of thanks was passed unanimously.

The CHAIRMAN: We must all appreciate the labour and time spent on these investigations by Mr. Lomax. He is one of the band of geologists or palæo-botanists,—if we may so call them—who have made Lancashire famous. I believe it was a few men whose daily occupation was in the cotton mills of Oldham who started this local study; it was a common thing for them to expose specimens of these calcareous nodules that they had collected, and to let them weather on the top of some wall surrounding a mill yard; these coal balls, so interesting to science, were however not of such attractive exterior as to tempt anyone to steal them, or interfere with them; and in time they would be taken away and cut into sections. Mr. Butterworth, I believe, was one of the first of this local band to slice them, and reveal their microscopic structure. As you see it has now developed into an important study. What was at first practically only a little hobby, taken up by a few Lancashire operatives, has become quite a science, and men of the highest attainments are giving their attention to it. These coal balls are composed simply of vegetable matter similar to that which forms the ordinary layers of coal. They have passed through some process of infiltration by carbonate of lime which has more or less preserved their structure. I take it that all our coal must have have had something of this vegetable structure, though it has become for the most part obliterated by chemical and mechanical change. It will not be astonishing then, that the tree which Mr. Hall has just mentioned, may be considered as upside down, or in any unnatural position, because we may find fragments of these coal plants massed together, which have been torn away from the parent stems, and consolidated by the action of lime or silica. It is mostly by the drifting of vegetable remains into basins or depressions, that the accumulations have thereby become the coal beds we are using up

to-day. Some of you may ask how lime came to penetrate the deposits, so as to preserve these specimens as we find them. It arose from the fact that there are in the measures above, a number of fossil shells. The lime which built up those shells has been dissolved, and has been concentrated by chemical action into these balls in the stratum of coal below, whence these specimens come. The preservation of these Carboniferous plants showing structure has taken place only in special localities. Oldham has become famous for them, as also Dulesgate, near Todmorden, and the neighbourhood of Halifax in Yorkshire.

Mr. JOSEPH DICKINSON desired to know how it was that these specimens showed the pith so well preserved, while the large fossil trees, often met with in mines, so rarely, if ever, had any.

Mr. GEORGE WILD said: I have listened with very great interest to all that Mr. Lomax has said. The paper will undoubtedly add a little needed palæo-botanical spice to the valuable geological and mining papers published in the Society's Transactions. The subject is not only an interesting one, but eminently serviceable in equiping the mining engineer with the essentials necessary to enable him to recognise true Coal Measure plants, in whatever part of the world he may be employed, a great desideratum in this age of discovery and development of stored-up fuel of the coal period. To be able to correlate the fossil plants found in the rocks in foreign countries with those of the true Coal Measures, which possess so wide a distribution, or to determine whether the measures under inspection belong to some other formation which occasionally furnishes coal of more or less value as fuel, yet of more uncertain persistence as workable seams, is no mean accomplishment, which, as our empire extends and our trade develops in newly acquired territories, will be individually, as well as nationally,

beneficial, and, no doubt, fittingly valued and remunerated. The correlation of certain Coal Measure plants in the various members of the Coal Formation has been studied by Mr. R. Kidston with a fair amount of success, and which it is to be hoped will, in the future, prove of great service in the investigation of unproved coalfields both at home and abroad. The palæontological evidence furnished by a close study of the horizons of the shells and fish remains, will no doubt, in the hands of scientific experts, yet become of great utility to the intelligent mining engineer, in the recognition of various parts of the coal series, which may, from lack of such evidence, have long been in a doubtful position.

Professor WEISS, on the invitation of the Chairman, said: Mr. Lomax has treated this subject so fully that there is very little to add, especially at this late hour of the meeting. I might say, however, regarding the last plant he mentioned—the Halonial branch of the *Lepidodendron fuliginosum* of Williamson—that I think he is correct in the identification, and Dr. Scott is of the same opinion. Mr. Kidston, however, disagrees with this view and thinks it belongs probably to *Sigillaria*. But I have gone into the matter very carefully. I have visited Mr. Kidston, and have seen his specimens, and must adhere to the first identification Mr. Lomax made. It has led me into a large inquiry regarding the *Lepidodendron fuliginosum* of Williamson, and it may result in finding that we have really two plants; this will be one of the forms, whilst another form will also exist which has a Halonial branch, with more than two rows of tubercles. I think there will probably be sufficient reason for distinguishing the two, or for supposing that this species had two forms of branches. It has led to a large amount of work, but it shows the fruitful character of this discovery which Mr. Lomax has made, and to the discovery must be added the admirable way in which he has prepared the

microscopic slides. With regard to the question as to the reasons for the presence of preserved pith in some specimens and its absence in others, I think some light might be obtained from a consideration of recent plants. There are, of course, cases where pith is absent in the living plant—in the Equisetum group, for instance, to which the calamites belong. In other forms we have tissues in the centre, constituting the pith, but the pith may disappear during the life of the plant; such a plant, when it becomes fossilised, would obviously not have any central tissue preserved, but even if the plant had up to its death retained the pith, then there might have been a certain decay going on before fossilisation took place, in which case again the central part would be less resistant, and be the first to be attacked. And so, in the larger trees found in the Coal Measures. We are dealing with stems in a state of decay, either preceding or after death, and generally these larger stems are devoid of pith, whereas the smaller stems found in the coal balls have their pith preserved, and yield these admirable sections.

Mr. LOMAX in replying thanked the members for the reception of his paper, and referred to the absence of pith in certain fossil plants, drawing attention to some specimens of *Stigmaria*, which retained the outer bark, with a central axis. The bark, he said, was well preserved; the intermediate tissue between the central axis and the bark was gone, the space having been filled with rootlets, and other portions of plants, showing that the intermediate portions must have decayed pretty quickly. The outer bark would not be above an eighth of an inch thick, and within this there was a central pillar. It was clear that these portions must have been very tough.

This concluded the business of the meeting.

DESCRIPTION OF THE PLATES.

PLATE I.

PHOT. 1.—An almost perfect transverse section of *Lyginodendron Oldhamium* (Will). *lt 1—lt 5*, five leaf traces passing through the pericycle; *lt Ra*, leaf trace about to pass outwards to form a petiole ("*Rachiopteris aspera*"); *x*, secondary wood; *p*, pith. Twice natural size.

PHOT. 2.—Portion of *lt 1* of Phot. 1 magnified 25 diameters. *lt*, leaf trace; *x*, secondary wood; *mr*, medullary ray.

PHOT. 3.—Another portion of Phot. 1, magnified 25 diameters. *p*, pith; *mr*, medullary ray; *x*, secondary wood; *px*, protoxylem.

PHOT. 4.—A fully developed petiole of *Lyginodendron Oldhamium* ("*Rachiopteris aspera*"). Magnified 4 diameters. *vb*, vascular bundles, corresponding to the leaf trace bundles *lt* of Phot. 1 and 2; *Dc*, *Dictyoxylon* cortex; *pd*, periderm.

PHOT. 5.—Transverse section of the root of *Lyginodendron Oldhamium* ("*Kaloxylon Hookeri*"); magnified 25 diameters. *px*, protoxylem; *ph*, phloem group.

PHOT. 6.—Tangential section of *Lyginodendron Oldhamium*, showing a root as it emerges from the *Dictyoxylon* cortex; magnified 8 diameters. *cy*, central cylinder; *x*, secondary wood; *c*, cortex.

All the figures on this plate are from specimens from Dulesgate, near Todmorden.

PLATE II.

PHOT. 7.—Radial section of *Lyginodendron Oldhamium*, from the same specimen as Phot. 1; magnified 50 diameters. *mr*, medullary rays; *th*, tracheïdes, shewing reticulated vessels.

PHOT. 8.—Tangential section of the same, magnified 50 diameters. *mr*, medullary rays; *th*, tracheïdes.

PHOT. 9.—Transverse section of a fully developed root of *Lyginodendron Oldhamium*; magnified 10 diameters. *px*, protoxylem; *ph*, phloem; *c*, cortex.

PHOT. 10.—Transverse section of *Lyginodendron Oldhamium* giving off a petiole ("*Rachiopteris aspera*") at *Ra 1*. Natural size. *Lyg 2*, oblique section of *Lyginodendron*, giving off a petiole at *Ra 2*; *Dc*, *Dictyoxylon* cortex.

PHOT. 11.—Transverse section of very small rootlet of *Lyginodendron* ("*Kaloxylon Hookeri*"); magnified 40 diameters. *px*, protoxylem; *x*, secondary wood.

PHOT. 12.—Portion of transverse section of a young *Heterangium Grievii*; magnified 12 diameters. *lt*, leaf trace bundles; *x*, secondary wood; *p*, pith.

All the figures on this plate are from specimens from Dulesgate, near Todmorden.

PLATE III.

PHOT. 13.—External view of "Specimen No. 2" shewing all the parts of the block where the *Medullosa anglica* is exposed; *2,2*, *3,3*, *4,4*, planes from which sections have been prepared. Phot. 16 is from one parallel to *4,4*, about 1½ inch from it, the intervening space being used for vertical sections. *aa*, the external surface of a petiole, extending the whole length of the block (*pet 1* in Phot. 16); *c*, another petiole which has split away; *bc*, a new petiole, which appears at about the line *s* shewn in Phot. 16, *pet. 2*. The petiole shewn in Phot. 16, *pet 3*, is not seen here as it lies at the back of the specimen. About two-thirds natural size. (Reduced from Dr. Scott's figure in Phil. Trans. Roy. Soc., 1899, by mutual arrangement.)

PHOT. 14.—Small portion of *Medullosa anglica* shewing portion of a stele, *st*; *lt*, leaf trace, commencing to develop its protoxylem; *pd*, periderm. Magnified 20 diameters.

PHOT. 15.—Portion of a transverse section of petiole of *Medullosa anglica*, magnified 10 diameters. *lt*, leaf trace bundles; *gc*, gum canals; *c*, cortex.

PLATE IV.

PHOT. 16.—Transverse section of *Medullosa anglica*, from the "No. 2 specimen" shewn on Plate III. *st 1*, *st 2*, *st 3*, the three steles, which are almost perfect; *pet 1*, *pet 2*, *pet 3*, the three petioles, or leaf stalks, *1* and *3* being almost free from the stem; *pet 2* is the one shewn at *bc* on Phot. 13; *oc*, outer cortex, or hypoderma; *lt*, leaf trace bundles; *vb*, vascular bundles; *pd*, periderm. Slightly enlarged. This section will pass into the collection of Mr. Geo. Wild.

PHOT. 17.—Transverse section of a large undivided leaf trace bundle being given off from stele No. 3 of Phot. 16; *px*, protoxylem; *x*, secondary wood extending all round except for accidental rupture; *ph*, phloem. Magnified 50 diameters. (After Dr. Scott, Phil. Trans. Roy. Soc., 1899.)

PHOT. 18.—Transverse section of a root of *Medullosa anglica* associated with "Specimen No. 2." *px*, the three protoxylem angles; *rt*, rootlet; *x*, secondary wood; *ph*, phloem; *pd*, periderm. Magnified 10 diameters.

PLATE V.

PHOT. 19.—Longitudinal section of a root of *Medullosa anglica*; *pd*, periderm; *x*, wood of root. Magnified 20 diameters. (After Scott.)

PHOT. 20.—Transverse section of root of *Medullosa anglica*; *pd*, periderm; *px*, wood; *x*, secondary wood; *rt*, the vascular strands of a rootlet. Magnified 20 diameters. (After Scott.)

PHOT. 21.—Vertical section through one of the steles of *Medullosa anglica*; *x*, secondary wood shewing the bordered pits of tracheïdes; *px*, spiral elements

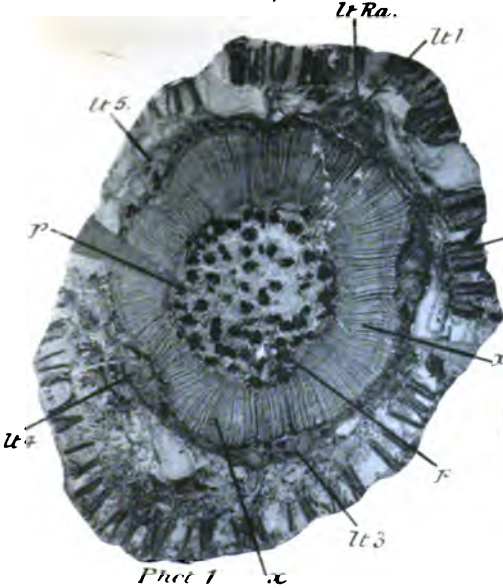
of protoxylem; *x2*, inner part of primary wood shewing the spiral or scalariform vessels. Magnified 125 diameters. (After Scott.)

PHOT. 22.—Transverse section of the *Lepidodendron fuliginosum* shewn on Plate VI., taken at the point *A*. *c*, cortex; *ic*, inner cortex; *ltb*, leaf trace bundles; *va*, vascular axis; *p*, pith; *s*, sheath of leaf trace bundles. Natural size.—Section now in the Manchester Museum, Owens College.

PLATE VI.

PHOT. 23.—A new Halonia-like form of *Lepidodendron fuliginosum*, of Williamson, before it was cut into sections. Natural size. One portion is now in the Botanical Laboratory of The Owens College, Manchester. Phot. 22 is the transverse section of this specimen.

The author has to thank Dr. Scott for allowing him to reproduce photographs 13, 17, 19, 20, and 21. All the others are from the author's own slides.



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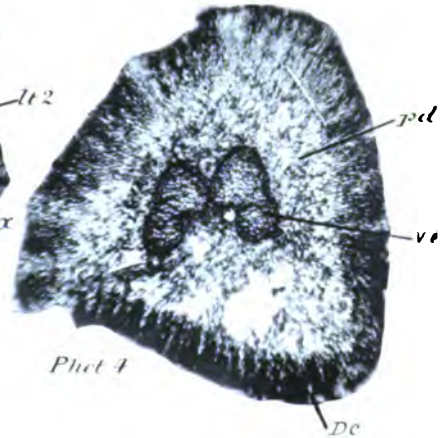

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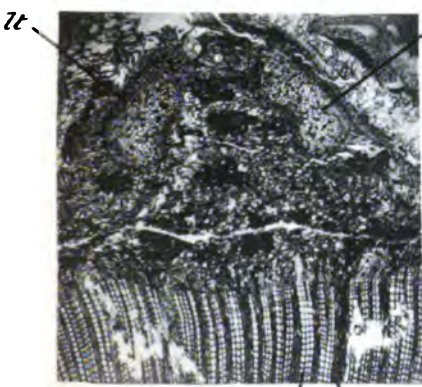

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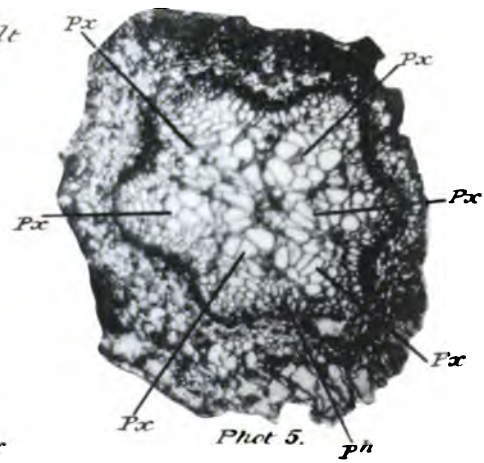

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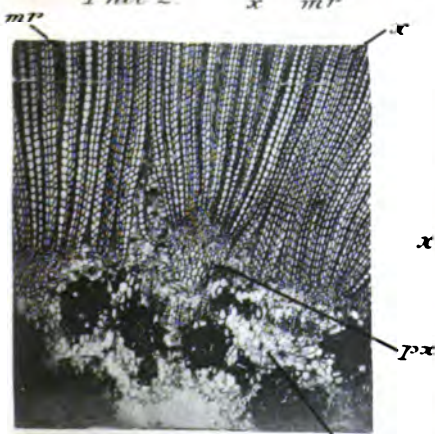

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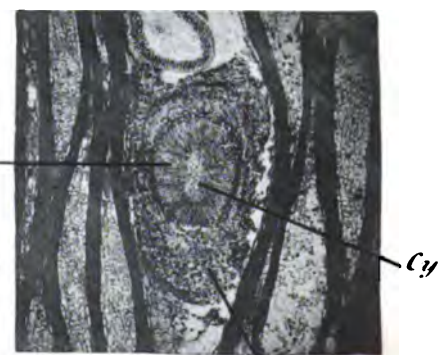
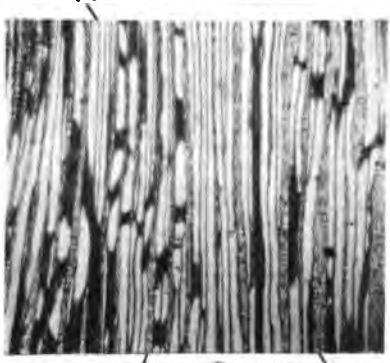


Phot 6

LYGINODENDRON OLDHAMIUM.

Phot. 7.



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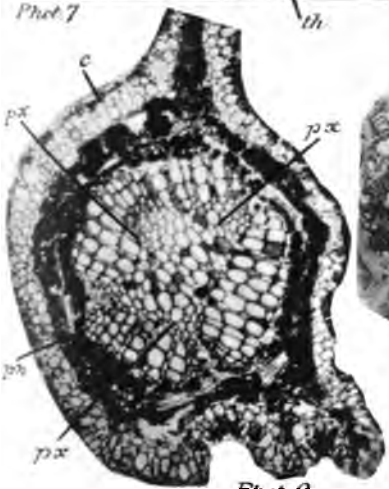

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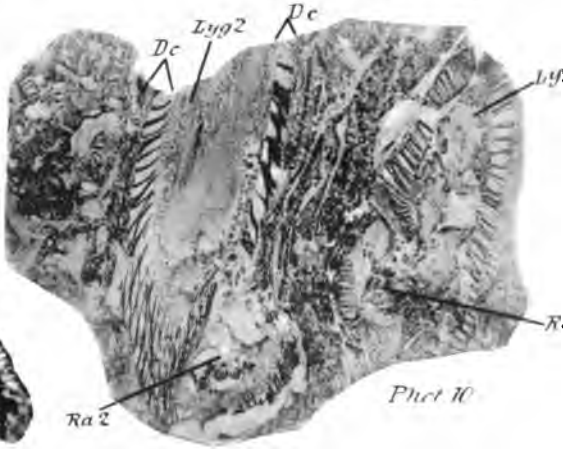
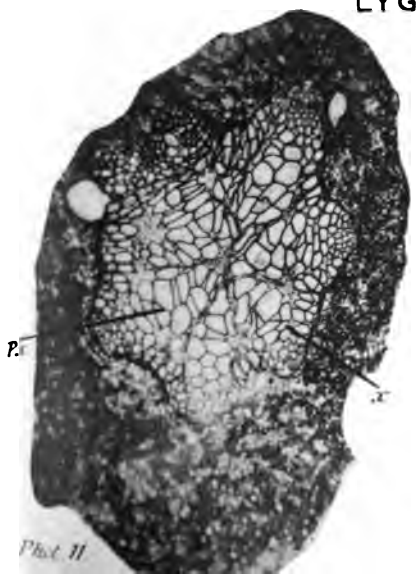


Phot. 10.

LYGINODENDRON.



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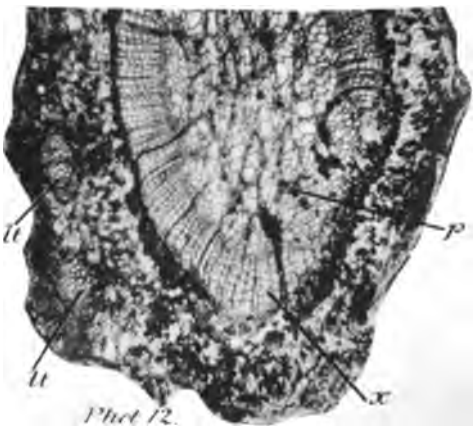
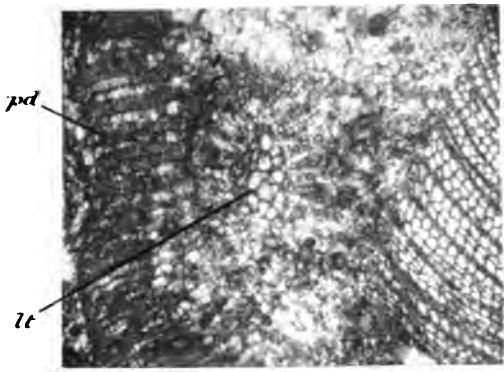
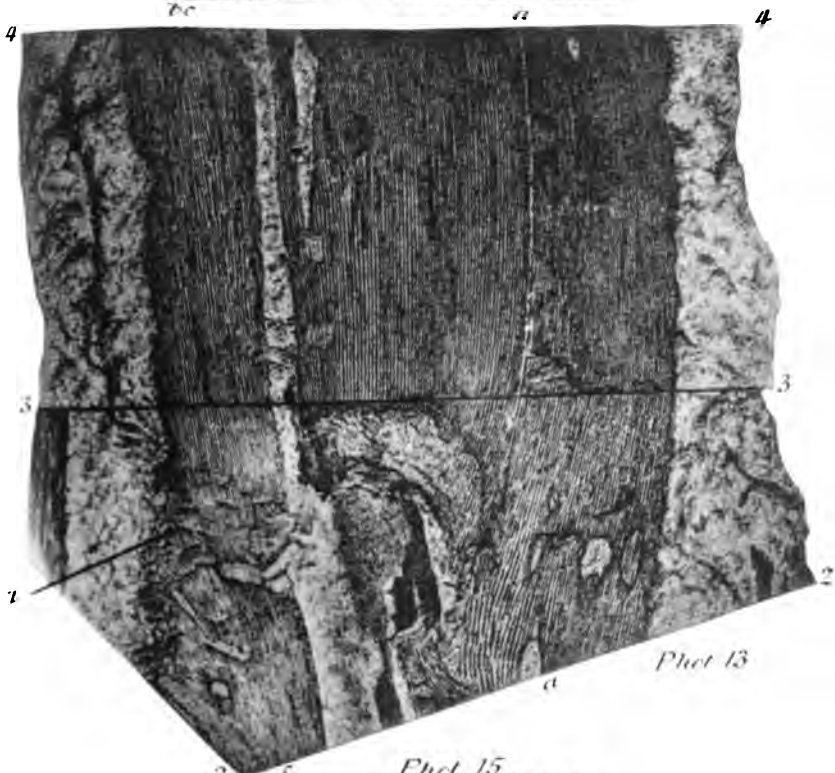


Phot. 12.

HETERANGIUM.

Phot 14

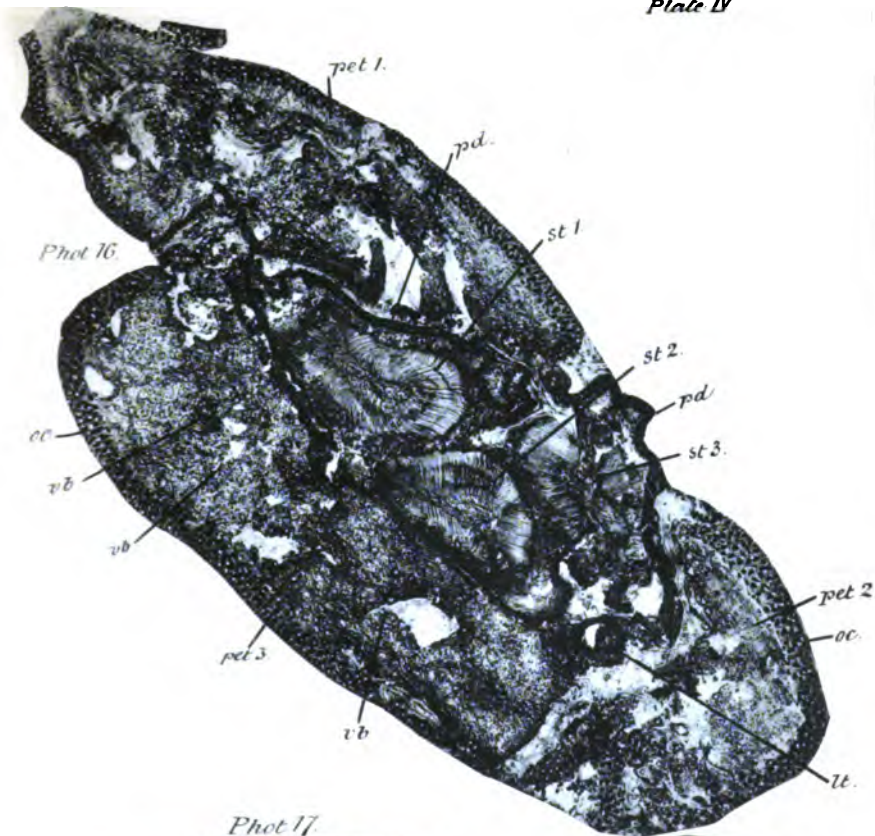


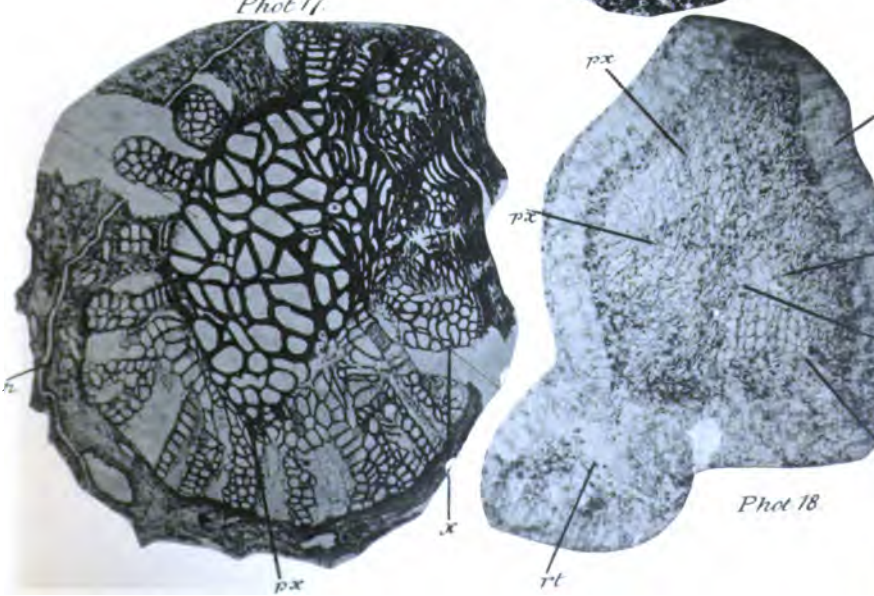


Phot 13

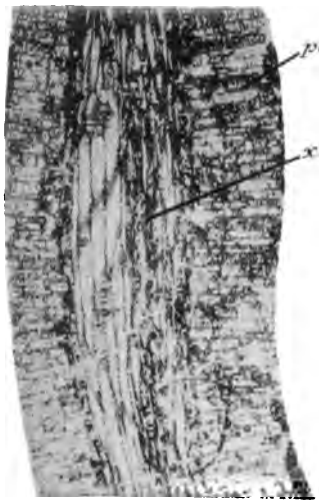
Phot 15

MEDULLOSA ANGLICA.

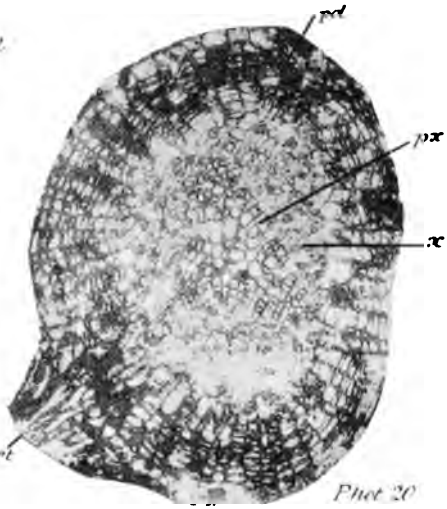




MEDULLOSA ANGLICA.



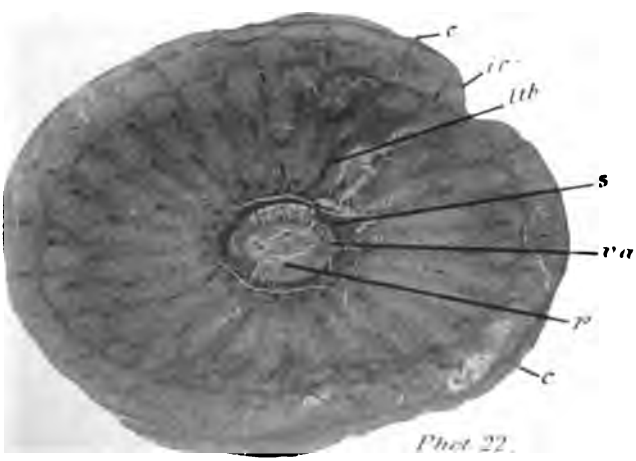
Phot. 19.



Phot. 20

Phot. 21.

MEDULLOSA ANGLICA.



Phot. 22.

LEPIDODENDRON FULIGINOSUM

LEPIDODENDRON FULIGINOSUM.

(of Williamson.)

EXCURSION TO LANGSETT, NEAR PENISTONE, TO VIEW THE NEW WATERWORKS OF THE SHEFFIELD CORPORATION, 15TH JULY, 1899.

On arriving at Langsett, Mr. WILLIAM WATTS, F.G.S., Engineer of the Little Don Valley Works, and a past President of the Society, met the party, and said :—

It gives me great pleasure to meet once again the members of the Manchester Geological Society, and to give them a hearty welcome to Langsett this afternoon.

Before asking you to accompany me over the great works, which the Corporation of Sheffield have placed in my hands to construct, I should like to say a few words generally on the geological and climatic conditions of the district. We stand in a position of advantage for the eye to wander over hill and valley scenery covering an area of about 20,000 acres. To the right of us the hills rise to an altitude of 1700 feet above the sea level, and fall to 500 feet at Stockbridge, in a distance of six miles, producing an average gradient of one in twenty-six.

With the exception of Warncliffe Crags in the distance, all the hills are mammillated and covered with vegetation common to elevated moorlands on the Pennine hills, and in a number of places trees adorn the crests.

Right away from Deepcar, the margin of the Little Don river is ornamented with trees and woody undergrowth. Many forest trees of healthy growth and stately size are met with, and in Sheephouse Wood some fine hollies grow.

The oak, ash, elm, and sycamore flourish abundantly Such a profusion of vegetation is not found on the Lancashire side of the Pennine Chain, where trees are rarely found except in sheltered places.

The Little Don is a typical moorland river. It winds in and out until it dies away unseen in the peat and heather on the moorland slopes. In seasons of drought it is reduced in volume of flow to ·028 cubic feet per second per 100 acres, and swells out in time of maximum flood to 30 cubic feet per second per 100 acres.

Although I have been at Langsett two years only, I have noticed that the climatic conditions are far more genial for plant and bird life than in the valleys on the other side of the Pennine Chain where I have been professionally engaged for so many years. The air seems to me drier and warmer, although the average rainfall is not much less.

Coming now to the geology of the district immediately around us. We stand on a thin covering of valley alluvium overlying the Rough Rock of the Millstone Grit series, and the elevated hills to the right of us bring to the surface in a few places the Kinderscout Grits, or the bottom beds of the series, but as yet I have not explored them. The Rough Rock is very good building stone, and is being used in the works before you. Its colour and texture are all that can be desired for reservoir purposes, and one could not have it more conveniently placed for the service of our works.

Immediately below the Rough Rock exists a bed of carbonaceous shale, about 200 feet in thickness. It contains many Goniatites and ironstone nodules, and forms the foundation for the concrete and puddle trench of the embankment, which you see opened out in front of you. The lower beds are full of water, which increases in volume with the depth, and has the character of maintaining a uniform temperature, winter and summer alike, of 50° F. No doubt these beds are extensive, and plunge under the Lower Coal series about a quarter of a mile down the valley—a fact which makes them very trustworthy and safe for the insertion of an impervious core for a deep reservoir.

Although I have diligently searched for boulder clay, and granite and other boulders, I have been unable to find them in Langsett valley—a fact worth notice.

It appears to me therefore that the agency of ice has not been active in the Little Don valley.

Quite a number of faults exist in the valley, and some beautifully contorted beds, which lend variety and interest to an eye trained to see.

I must not conclude my remarks without some reference to the hydraulic works which in the main you have come to Langsett to see.

The embankment before you, staked out by the profiles on either slope, will, on completion, be the largest belonging to Sheffield. It will require nearly a million cubic yards of earth and puddle to make it, in addition to about 30,000 cubic yards of cement concrete in the trench below the surface of the ground.

Considerable volumes of water found their way into it along the bed planes of the shale; this had to be pumped out at the rate of 30,000 gallons per hour for several months, and the flow does not cease till the surface of the valley is reached, but as may be expected the rate of pumping is reduced as the re-filling proceeds.

The beds dip north-east at a slight angle, and are fairly uniform throughout. One exception however to this rule was met with in the middle of the valley, where some curiously contorted beds were intercalated with bands of clayey or crushed material, but they disappeared at a depth of 100 ft. below the surface, and normal floors of shale came in. Curiously enough the area of contorted shale yielded very little water. Indeed it was practically dry, but on either side the largest influx appeared and remained almost unabated to the last.

To deal successfully with large volumes of water under great pressure taxes the abilities of engineers to keep it out of the matrix forming the central core of the embankment, and from lifting or disturbing it during the time of setting. Kept to the sides it does no harm, but practical engineers know how difficult it is to divert a deep-seated spring from the course nature has provided for it.

By far the larger influx of water comes in on the higher or uphill side of the trench, and it was interesting to observe how persistently it kept to the ducts giving it birth, during subsequent sinking, necessitating brattice cloth to be used to prevent it splashing on the men working underneath. All the water flows along the bed planes. Indeed there are very few vertical joints in the shale in which the trench is cut. I noticed also that it was practically impossible to force the water horizontally by putting in a block of concrete in any particular part, and I took advantage of this phenomenon to refill the wettest part first to save pumping, which answered admirably.

After an inspection of the plans of the works in the Engineer's office, the members of the party were conducted by Mr. Watts, first through Langsett village, where they viewed the iron dwellings of the men engaged in the work, and the canteen, mission, and recreation rooms provided for their use by the Sheffield Corporation. Thence over the works, where they observed the progress made with the construction of the reservoir since the commencement, in October, 1897. The first portion of the work inspected was the discharge tunnel, leading to the valve well or shaft. The total length of this tunnel is about 400 yards, the shaft being in the centre. Mr. Watts explained how, at this point, the supply of water will be governed by valves connected with a vertical pipe, worked by hydraulic pressure. In the well

will be fixed a pipe, 43 inches in diameter, which will carry away the water for consumption, subsequently supplying other pipes for the needs of the citizens of Sheffield, and also to meet the compensation claims. Mr. Watts described the positions of the valves, and added that they had now carried the well up 41 feet. There was a consensus of opinion that the solidity of the foundations had been well studied, and the critics were not slow in expressing their admiration of the way in which the masonry had been carried out. In connection with the valve well, it may be interesting to state that the total capacity of the reservoir is fourteen hundred million gallons, and the maximum discharge will be about 70,000 cubic feet per minute in flood time. It may be imagined that the springs of water have been a source of great difficulty in the construction of the foundations; but it is satisfactory to know that this has now been surmounted.

Mr. Watts showed the extent of the reservoir, the area being 120 acres, and the greatest depth 100 feet. Having spent a short time in examining the formation of the land, the party examined the bed of the embankment, which is to stretch four hundred yards across the Don Valley in order to dam up the water. When the tremendous force of water that this embankment will be called upon to resist is taken into consideration, the importance of the engineering work in connection with this part of the reservoir cannot be overestimated. The average depth of the trench is 85 feet; at one point the depth was 119 feet, this being its deepest part. The excavation of the trench has been practically completed, and the work of making the base of the embankment was viewed with great interest on Saturday afternoon. Concrete is being used, and will be carried to within a few feet of the surface; every care is being taken in order to ensure the stability of the basis of the dam. At

the base the embankment will be 630 feet wide, and at the top 28 feet. Mr. Watts also described the gathering grounds comprised in the 5,200 acres belonging to the Corporation, and the many ways in which the spot has been endowed by Nature as the source of a great water supply. He intimated that it was hoped that the reservoir would begin to fill in four years from the present time.

On the motion of Mr. Stirrup, seconded by Mr. Ridyard, a hearty vote of thanks was passed to Mr. Watts, who in briefly replying, said he hoped that the Society would revisit the works next year.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART X. VOL. XXVI. SESSION 1899-1900.

The ANNUAL MEETING of the Members was held on Tuesday, October 10th, 1899, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. MARK STIRRUP, Vice-President,
in the Chair.

NEW MEMBER.

Mr. ROGER TATHAM, 51, Oxbury Avenue, Fulham, London, S.W., was balloted for and duly elected a Member of the Society.

THE ANNUAL REPORT AND TREASURER'S STATEMENT.

Mr. LINDSEY, one of the Honorary Secretaries, read the Report of the Council for the Session 1898-99.

REPORT OF THE COUNCIL,

For the Session 1898–99.

The Council, in presenting their Sixty-first Annual Report, have pleasure in recording the satisfactory results of the past years' work as follows:—

The Annual Meeting, six Ordinary Meetings and one Special Evening Meeting were held in the Society's Rooms, 5, John Dalton Street, Manchester, and two Ordinary Meetings were held, as usual, in the Mining School, Wigan.

Fifteen new members have been elected, and one has been re-instated.

The losses include one honorary member and four ordinary members by death, and eleven by resignations.

There has been a net increase of one ordinary member and a decrease of one honorary member.

Two members have compounded for their subscriptions by paying the life composition of £10.

The Society now consists of:—

Honorary Members	11
Life Members	10
Ordinary Members	212
Total	233

The members may be congratulated upon the papers read during the Session, which have been printed in the Society's Transactions, but it is hoped that the contributions may be even more liberal in the coming year.

Papers on subjects relating to mining have been read by Mr. James Keen, Mr. John Gerrard, Mr. W. J. Orsman, and Mr. Harrison Deans.

Geological subjects were brought forward by Messrs. W. F. Holroyd and J. Barnes, Dr. Wheelton Hind, Mr. Mark Stirrup, Mr. G. H. Morton, and Mr. James Lomax.

The British Association Loan Collection of Geological Photographs was exhibited by Mr. C. R. Lindsey, many of them being shown by the aid of the lime-light, at the Special Evening Meeting.

Valuable Geological Specimens were exhibited by Messrs. Holroyd and Barnes, Mr. Mark Stirrup, Mr. Joseph Dickinson, Mr. James Lomax, Mr. Henry Hall, Mr. Ryans, Mr. Dobbs, Mr. Hughes, and Mr. Saint.

A complete list of the papers and short communications read during the Session is appended.

Members are reminded that the usual technical journals, and the publications from kindred Societies with whom we exchange transactions, continue to be received, and that these, together with the books and geological maps, are available for reference on week-days between the hours of 9-30 a.m. and 5-30 p.m., except on Saturdays when the Rooms are closed at 1 p.m.

The Library is very valuable and forms an important asset of the Society. It contains a large number of standard works on mining and geological subjects, besides numerous pamphlets, maps and sections. The Council regret to state that, owing to the necessarily large expenditure in connection with the present Rooms, they have been unable to devote a sufficient amount to the purchase of recent works, or to the binding of the books. They would be pleased to receive donations of works from members who desire to add to its usefulness and thereby confer a lasting benefit on the Society.

The Society continues on the list of Corresponding Societies of the British Association, and Mr. Mark Stirrup,

at the request of the Council, very kindly acted as your delegate at the meetings held at Bristol in 1898, and at Dover in 1899.

The Council regretfully record the death of the President and Treasurer, Mr. Clegg Livesey, who at various times had held every office in the Society, and whose long and valuable services were highly appreciated; also of Mr. Samson Garside, a Vice-President, and Mr. Thomas Livesey, and Mr. John Iles; and also M. Brongniart, an Honorary Member.

From a financial point of view the year has been a fairly satisfactory one, as shown by the accompanying Statement of Accounts.

The attendances at the meetings have been, on the whole, larger than usual, and much interest has been evinced in the discussion of the various papers.

The Council have pleasure in recording their indebtedness to the Governors of the Mining School, Wigan, for the use of the Lecture Hall, in which the January and May meetings were held; to the authors for their respective communications; and to Mr. William Watts, one of the Past-Presidents, for conducting an excursion of the members to view the new water-works in the valley of the Little Don, at Langsett, belonging to the Sheffield Corporation, on July 15th, an account of which appears in Part IX., Vol. XXVI.

In conclusion, the Council appeal to the members generally to further the interests of the Society by individual effort, in securing new members, by increased attendances at the meetings, and in contributing papers for discussion.

Mr. Lindsey also read the following abstract of the Treasurer's Accounts :—

MANCHESTER GEOLOGICAL SOCIETY.

ABSTRACT OF THE ACCOUNTS FOR THE SESSION 1898-9.

Dr. *Cr.*

Receipts.	£	s.	d.	£	s.	d.
To Cash in Secretaries' hands				1	11	2
,, Members' Subscriptions:—						
Life	20	0	0			
Current	184	10	0			
Arrears	32	10	0			
				237	0	0
,, Transactions subscribed for and sold				10	19	7
,, Birkenhead Railway Dividends				23	4	0
,, Lancashire & Yorkshire Railway Dividends				21	5	2
,, Letting of Rooms				3	0	0
,, Bank Interest				0	9	7
				£297	9	6

Payments.	£	s.	d.
By Balance due to Treasurer	5	13	1
,, Expenses of Rooms	106	2	1
,, Printing Transactions	87	12	6
,, Circulars and Stationery	9	17	6
,, Postages	16	15	11
,, Reporters	9	9	0
,, Library	9	13	11
,, Fire Insurance	0	12	6
,, Sundries	0	16	8
,, Collectors' Commission	12	9	0
,, Balance in the Bank	38	7	4
	£297	9	6

BALANCE SHEET, 30th September, 1899.

Dr. *Cr.*

Liabilities.	£	s.	d.
To Outstanding Accounts	61	5	3
,, Balance	2072	2	1
	£2133	7	4

Assets.	£	s.	d.
By £600 Birkenhead Railway 4% Consolidated Stock (Guaranteed) at 135	810	0	0
,, £733 Lancashire and Yorkshire 3% Consolidated Preference Stock at 103	755	0	0
,, Library and Furniture insured for	500	0	0
,, Cash in Bank	38	7	4
,, Arrears of Subscription considered good	30	0	0
	£2133	7	4

Signed on October 6th, 1899, by

CHAS. R. LINDSEY, Treasurer.
GEO. H. HOLLINGWORTH, Auditor.

The CHAIRMAN said: Members will quite understand that the expenses of our present rooms are much heavier than those of the rooms in George Street, which were occupied so long under the Literary and Philosophical Society. That is the reason, no doubt, why we have not a little balance left for investment. Ever since we came here we have been unable to make any addition to our investments. To keep down expense and increase the number of members is what we have to look after. I move the adoption of the Report and Balance Sheet.

The motion was seconded by Mr. HOLLINGWORTH, and unanimously carried.

ELECTION OF OFFICERS.

The CHAIRMAN said: Our next business will be the election of officers for the ensuing session. The Council have, as has been their custom, prepared a list of gentlemen, eligible for the various offices, to submit to this meeting, but members will understand that they are not bound to adopt this selected list, but that anyone is at liberty to propose other names in their places. The retiring Council have no wish to press forward the name of any gentleman, but it has been found convenient, in order to facilitate business, to come before the meeting each year with a list of gentlemen which they recommend for your adoption. For the office of President Mr. W. S. Barrett, J.P., is proposed. It was our misfortune last year to lose our President (Mr. Clegg Livesey) by death during his term of office; and Mr. Livesey, besides being President and Treasurer of the Society was also one of our Trustees.

Mr. Barrett was unanimously elected President, on the motion of Mr. HOLLINGWORTH, seconded by Mr. PEACE; and

the following Vice-Presidents were also elected:—Mr. G. H. Hollingworth, Mr. W. F. Holroyd, Mr. G. Peace, and Mr. S. S. Platt. Mr. G. H. Hollingworth was also elected Hon. Treasurer, and Mr. Mark Stirrup Hon. Librarian.

With regard to the vacant office of Trustee, Mr. STIRRUP said: It has already been intimated that we have lost one of our Trustees, Mr. Clegg Livesey, by death. His co-trustee, Mr. Dickinson, however, survives, and is with us. Mr. Lees Knowles, M.P., has, I am glad to say, consented to fill the vacant Trusteeship. The office is an important one, and it is a matter of great satisfaction to us that Mr. Knowles has intimated his willingness to accept it. Perhaps some gentleman will formally move his appointment.

Mr. G. H. HOLLINGWORTH moved that Mr. Lees Knowles, M.P., be appointed a Trustee in place of the late Mr. Clegg Livesey.

The motion was seconded and carried unanimously.

For the office of Auditors Mr. J. Barnes and Mr. G. H. Winstanley were unanimously elected.

Mr. STIRRUP said that Mr. Lindsey, one of the Hon. Secretaries, wished to be relieved of his office, but his colleague, Mr. Saint, would continue his services. Though he retired from the Secretaryship they hoped to have Mr. Lindsey's services on the Council during the coming year. For the vacancy caused by his retirement Mr. J. Tonge, Junr., the son of an old and esteemed member of the Society, had been suggested, and he would, if elected, no doubt render valuable assistance in the Secretaryship.

Mr. J. S. BURROWS moved the appointment of Mr. J. Tonge, Junr., as joint Honorary Secretary with Mr. W. Saint.

The motion was seconded by Mr. BARNES, and unanimously adopted.

Mr. STIRRUP said the following was the suggested list of other members of the Council, and he would move its adoption:—Mr. J. Atherton, Mr. J. Barnes, Mr. J. Crankshaw, Mr. J. Gerrard, Mr. G. C. Greenwell, Junr., Mr. G. B. Harrison, Mr. C. R. Lindsey, Mr. D. H. F. Mathews, Mr. A. Dury Mitton, Mr. Thomas Scowcroft, Mr. J. Unsworth, and Mr. L. B. Wells.

The adoption of the list, as proposed, was seconded by Mr. JAMES TONGE, and unanimously agreed to.

Mr. STIRRUP said he wished before inviting the new President to give his promised address to mention that Professor Hull, F.R.S., F.G.S., had kindly promised during the Session to come and deliver a lecture to the members of the Geological Society and the Manchester Field Club. The date had been fixed for Thursday, November 9th, and the Principal of Owens College had granted the use of one of the Lecture Theatres of the College for the purpose. Professor Boyd Dawkins had promised to preside, and Mr. Stirrup hoped there would be a good attendance of members and their friends. The title of the lecture would be "Sub-oceanic Terraces and River Valleys off the coasts of the British Isles and Western Europe," illustrated by maps and lantern slides.

THE PRESIDENT'S ADDRESS.

The President (Mr. W. S. Barrett) then took the Chair, amidst cheers, and delivered the following address :—

Before I begin my address I desire most heartily to thank the members of the Society for electing me to the honourable position of President, and to say that looking back to the long line of eminent and learned men who have occupied the Presidential chair, I feel deeply the honour bestowed on me, and the greatest diffidence in accepting the position. I can only say the knowledge of the ability and brilliancy of my predecessors will act as an incentive to me to follow, however unworthily, in their footsteps, and to endeavour to maintain in as high a degree as possible the interests and aims of the Society.

It is quite impossible for me to address the Society on subjects geological. My whole business life has been spent in commercial pursuits, and anything I have learned as to the mysteries of Mother Earth has been gained by attending our meetings and listening to papers and discussions on the various matters which have come before the Society.

Some exception has occasionally been taken to the title, "Manchester Geological Society," and to the fact that many of its papers have little relation to geology. Probably if the Society were now commencing it might well be styled the "Manchester Mining and Geological Society," but after all, the aim and work of the Society is well understood, and no doubt greatly appreciated.

Geology and mining are twin sisters, and the combination of the theoretical and practical in the records of the Society is a happy one. Some of our past Presidents have been geologists of the highest order, and also giants in mining

experience and talent. Others could claim no special geological knowledge nor that of practical mining, but being closely associated with both as having interests in mine ownership, and being engaged in mining commerce, were a connecting link between one and the other. To the latter class I have the honour to belong. During more years than I care to record I have attended the Society's meetings, and have followed the proceedings with the greatest interest, and believe the works of the members both in the Society and outside has exercised a by no means unimportant influence on all that appertains to the welfare of the mining industry. During the half century or so which covers the existence of the Society there have been very considerable changes in connection with mining, and what was comparatively a small occupation has developed into one of the greatest industries of the United Kingdom, and in that development the area of the Society comprising chiefly the County of Lancaster has done its full share. I will not trouble you with many figures, but would just point out that in 1854 the production of coal was well under 50,000,000 tons, while in 1897 it had risen to over 200,000,000. The number of persons employed during the same period had risen from 236,000 in 1854 to 695,000 in 1897. Mine inspectors have been created since the formation of the Society, and it is not too much to say that the excellent effects in the increase of safety without unduly harassing the work done has been due in great measure to the high character and talents of the mining inspectors, of whom we have some illustrious examples in the membership of our Society. Those gentlemen will, I am sure, take no exception to my remarking that the colliery proprietors of Lancashire and Cheshire, at any rate, may claim to have had an important share in the good work that has been done as regards increased efficiency and diminished danger; indeed, in this latter respect the county of Lan-

caster has not only been in advance of other parts of the United Kingdom, but in advance of Parliament itself, and very many colliery owners have voluntarily adopted safety appliances before such arrangements have been specially legislated on. To give one illustration I would here remark that the proportion of fatal accidents to persons employed which in 1854 was 1 to every 225, in 1897 had diminished to 1 in 803. I venture to think that mining in the future will tax even more than in the past the skill of mining engineers, and possibly the pockets of coal owners. The mines that have to be worked are deeper than those which our forefathers expended their capital and energies on, and not only will that increased depth demand greater skill and economy, but the difficulties in getting down to the mines, in many cases through heavily watered strata, will be proportionately increased. I need no excuse for mentioning this, as our Transactions, (and those of a very recent period), give evidence of how these difficulties have in the times in which we are living been overcome. I have no fear that valuable mines in the United Kingdom will remain permanently unworked through lack of skill and enterprise.

There has been in past years something like an oratorical competition amongst Presidents of mining institutes with regard to the so-called rapid exhaustion of our coalfields, and no doubt they are diminishing at a very much greater rate than would have been deemed possible even a few years back. An output of over 200,000,000 tons per annum is a substantial diminution of our stores of black diamonds, but I am by no means a pessimist in this matter, and am of opinion that some few centuries will elapse before the coalfields of the United Kingdom will enter on the downward grade so far as the supplies are concerned, nor have I any sympathy with proposals for restricting the output of coal or putting a tax on its export. I hope the conditions which

have made the coal trade of the United Kingdom a great factor in our national welfare will continue, but at the same time I hope that everything will be done that is possible to avoid waste in consumption, and to secure economy in production, and as a commercial man I cannot help expressing the hope that severe competition will be avoided, and that without improper combination such reasonable prices may be obtained as will command a reasonable return for the capital embarked and skill employed in this great industry. It is not in our power to restore or renew any part of the nation's mineral wealth, but it is our bounden duty to see the coal sold at reasonable prices. The signs of the times are that a better feeling exists between employer and employed, and is more likely to grow than has been the case in times past. This I hope to see extended, as it is conducive to a better state of things all round.

I am quite aware that compared with past Presidential addresses the remarks I have ventured to offer may be considered tame, and by some perhaps unprofitable, but you must bear in mind that I am neither a geologist nor a specialist in mining engineering, but one who has been identified with mining all my business life, and endeavoured to take a keen interest in and promote where possible anything that would benefit in any way the mining community. One influence of the Manchester Geological Society by its papers and discussions is unquestionably educational, and it is a matter for great gratification that perhaps more has been done in the matter of special mining education in Lancashire than in any other county of the United Kingdom. It is important alike to efficiency and safety that both the officials and working element at collieries should have the opportunity of scientific training to assist and alleviate the practical working of the mine. The amount of scientific training will vary, and while those who have to hold

responsible positions will receive it in a higher degree it is most important that the workmen should enjoy it to some extent at any rate, more especially as many of those holding high positions at collieries have risen from the ranks. The city of Manchester, in which most of our meetings are held, is renowned for the Owens College, which probably has no superior within the British realm. In the town of Wigan, where also meetings are held each year, after forty years of pioneering by devoted spirits, who amongst difficulties of the most trying kind did not know the meaning of the word "fail," active operations have been commenced for the erection of expensive and elaborate buildings suitable for mining and technical schools, and there is every reason to believe that at the commencement of the 20th century the officials and workmen of the Lancashire coalfields will have available a mining and technical school equal to all requirements. I venture to say for the Manchester Geological Society that we recognise the valuable work which the leaders of mining education are doing, and wish them success. I have said nothing of the influence of Parliament except a few words at the commencement of this address of a eulogistic character referring to mining inspection. There is little more to be said except that while I fully and frankly recognise the good which Parliament has done I think our legislators may well pause before they spoil their work with over legislation. It is much easier to pass a bad Act of Parliament than a good one, and it is most difficult to remedy the effects of the former. There is a tendency to interfere where interference is not only harassing but dangerous, and there is no industry where more efforts have been made, and made successfully, to minimise the dangers incidental to it, and to work under the most approved and practical conditions. I may venture to express the hope that every encouragement will be given to those who desire

to accomplish so desirable an end. I must again lament my non-ability to give you such a paper as the Society has been accustomed to receive from its Presidents, but hope that a few plain thoughts in connection with what has occupied all my business life may not be unacceptable.

On the motion of Mr. DICKINSON, seconded by Mr. BURROWS, the cordial thanks of the meeting were given to the President for his address.

In reply the PRESIDENT said: I am exceedingly obliged to you, gentlemen, for this vote of thanks. As I before said, I am fully aware of the responsibilities of the office to which you have elected me, and I felt, in making a few remarks upon taking the Chair, that they were different from what you have been accustomed to in previous years; but, having done me the honour of electing me, you must take me as I am. I should not think of giving a paper on geology, in the presence of gentlemen whom I see before me; at the same time my heart is with you, and anything I can do to further the interests of the Society shall be most gladly done.

On the motion of Mr. DICKINSON, seconded by Mr. WELLS, the best thanks of the Society were given to the retiring officers of the Society.

LIST OF PAPERS AND SHORT COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE

SOCIETY DURING THE SESSION 1898-99.

1898.

October. Holroyd, W. F., and Barnes, J. "On Minerals, Fossils, and Flint Implements exhibited."

November. Holroyd, W. F., and Barnes, J. "On the Superposition of Quartz Crystals on Calcite in the Igneous Rocks occurring in the Carboniferous Limestone of Derbyshire."

Stirrup, Mark. "Report of the Delegate to the British Association Meeting, at Bristol, 1898."

December. Lindsey, C. R. "British Association Loan Collection of Geographical Photographs."

Stirrup, Mark. "Coal Fossils from Agecroft."

Hind, Wheetton. "On the Correlation of the British and European Carboniferous Beds."

1899.

January. Keen, James. "Description of Sinking Two Shafts through Heavily Watered Strata at Maypole Colliery, Abram, near Wigan, for the Moss Hall Coal Company."

February. Dickinson, Joseph. "Striated Boulder from Blackpool."

Stirrup, Mark. "A Septarian Nodule."

Gerrard, John. "An Outburst of Gas at Westleigh Colliery."

"Notes on an Outburst of Fire-damp at Blainscough Colliery."

March. Stirrup, Mark. "The Earthquake of February 27th."

"Occurrence of a Gypsum Boulder at Blackpool."

Stirrup, Mark. "On the Value of the Fossil Plants of the Coal Measures as Stratigraphical Guides."

April. Dickinson, Joseph. "Boiler Explosions."

Morton, G. H. "Description of a New Geological Map of Liverpool."

Barnes, J., and Holroyd, W. F. "On the Subterranean Excavation in Limestone Areas, and a consideration of the Atmospherical, Physiological, and Hygienic conditions produced thereby."

1899.

May. Deans, Harrison. "The Pneumatophor Rescue Appliance for Use in Mines."

Orsman, W. J. "On Permitted Explosives."

June. Hall, Henry. "Fine Slickensides in Cannel." "Possible Case of Inversion of a Fossil Tree."

Lomax, James. "Recent Investigations on Plants of the Coal Measures."

NEW ORDINARY MEMBERS.

Clark, George F.
Douglas, Ernest
Downham, William
Goodwin, John
Hampson, Joshua
Hollingworth, David
Laverick, John H. W.
Leigh, Oswald B.
Pilkington, Lawrence
Selby, John B.
Shaw, Alfred
Tansley, A. E.
Tonge, James, Jun.

NEW LIFE MEMBERS.

Eagle, George
Hall, Levi J.

MEMBER RE-INSTATED.

Fletcher, Thomas.

HONORARY MEMBER DECEASED.

Brongniart, Charles.

MEMBERS DECEASED.

Garside, Samson
Iles, John
Livesey, Clegg.
Livesey, Thomas.

MEMBERS RESIGNED.

Bradford, Earl of
Campbell, H. H.
Fletcher, Norman
Foster, John W.
Keirby, John E.
Mercier, Maunsell
Morris, Moses
Munro, Donald
Purdy, Richard
Thompson, Peter
Whewell, John.

The following is the complete list of the Council for the ensuing year :—

President:

W. S. BARRETT, J.P.

Vice-Presidents:

GEORGE PEACE. | G. H. HOLLINGWORTH, F.G.S.
W. F. HOLROYD, F.G.S.
S. S. PLATT, F.G.S., M.Inst.C.E.

Ex-Officio Vice-Presidents:

R. CLIFFORD SMITH, F.G.S.
The Right Hon. the EARL OF CRAWFORD & BALCARRES.
Sir U. J. KAY-SHUTTLEWORTH, Bart., M.P.
G. C. GREENWELL, F.G.S. | EDWARD PILKINGTON, J.P.
Professor W. BOYD DAWKINS, M.A., F.R.S., F.G.S.
JOSEPH DICKINSON, F.G.S.
HENRY HALL, H.M.I.M. | JOHN S. BURROWS F.G.S.
JAMES TONGE, F.G.S., Assoc.M.Inst.C.E.
W. SAINT, H.M.I.M. | W. WATTS, F.G.S.
ROBERT WINSTANLEY, C.E. | MARK STIRRUP, F.G.S.
JOHN RIDYARD, F.G.S.

Hon. Treasurer:

G. H. HOLLINGWORTH, F.G.S.

Hon. Secretaries:

WILLIAM SAINT, H.M.I.M. | JAMES TONGE, Jun., F.G.S.

Other Members of the Council:

JAMES ATHERTON.
J. BARNES, F.G.S.
JOSEPH CRANKSHAW, F.G.S.
JOHN GERRARD, H.M.I.M.
G.C.GREENWELL, Jun., F.G.S.
GEO. B. HARRISON, H.M.I.M.
C. R. LINDSEY, B.Sc.
D. H. F. MATHEWS, H.M.I.M.
A. DURY MITTON.
THOMAS SCOWCROFT.
JOHN UNSWORTH.
LIONEL B. WELLS, M.Inst.C.E.

Hon. Librarian:

MARK STIRRUP, F.G.S.

Hon. Auditors:

J. BARNES, F.G.S. | GEO. H. WINSTANLEY, F.G.S.

Trustees:

JOS. DICKINSON, F.G.S. | LEES KNOWLES, M.A., LL.M., M.P.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-39-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-46-47	Moseley, Sir Oswald, Bart.
1847-48-49	Thicknesse, Ralph, M.P., Wigan
1851-52-53	Black, James, M.D., F.G.S.
1853-54-55	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-61	Kay-Shuttleworth, Sir, J.P., Bart., M.P.
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-64-65	Knowles, Andrew.
1867-8-9, 84-5	Greenwell, G. C., F.G.S., M.Inst.C.E.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3, 88-9	Knowles, John, M.Inst.C.E., J.P.
1873-74	Knowles, Thomas, M.P.
1874-5, 6-7, 86-7	Dawkins, Prof. W. Boyd, M.A., F.R.S., F.G.S.
1875-76	Smith, R. Clifford, F.G.S.
1878-79	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-81	Kay-Shuttleworth, Sir Ughtred J., Bart., M.P.
1881-82	Gilroy, George, M.Inst.C.E.
1883-84	Pilkington, Edward, J.P.
1885-86	Ormerod, Henry Mere, F.G.S.
1889-90	Hall, Henry, H.M.I.M.
1890-91	Burrows, John S., F.G.S.
1891-92	Tonge, James, F.G.S., Assoc.M.Inst.C.E.
1892-93	Peace, Maskell William, F.G.S.
1893-94	Saint, William, H.M.I.M.
1894-95	Watts, William, F.G.S.
1895-96	Winstanley, Robert, C.E.
1896-97	Stirrup, Mark, F.G.S.
1897-98	Ridyard, John, F.G.S.
1898-99	Livesey, Clegg, J.P.

APPENDIX TO THE REPORT.

ADDITIONS TO THE LIBRARY, 1898-9,

To September 30th, 1899.

Barnsley.—Midland Institute of Mining, Civil, and Mechanical Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Belfast.—Natural History and Philosophical Society. Report and Proceedings for Session 1897-98. *From the Society.*

Birmingham.—South Staffordshire and East Worcestershire Institute of Mining Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Bradford.—Annual Report (28th) of Libraries and Art Museum Committee.

Bristol.—Naturalists' Society. Proceedings. New Series, Part 3, Vol. VIII.

Bristol.—Museum. Report. *From H. Bolton.*

Cambridge.—Museum. 33rd Annual Report Museums and Lecture Rooms' Syndicate for 1898; also Annual Report of the Library, 1898. *From the Woodwardian Museum.*

Cardiff.—Naturalists' Society. Report and Transactions for 1897-8. Vol. XXX. *From the Society.*

Cardiff.—South Wales Institute of Engineers. Proceedings Nos. 2, 3, 4, 5, Vol. XXI. *From the Institute.*

Chester.—28th Annual Report of Chester Society of Natural Science and Literature. *From the Society.*

Chesterfield and Midland Counties Institute of Engineers.—Proceedings. No. 8, Vol. XXII. Parts 1 and 2, Vol. XXIII. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Dublin.—Royal Society. Transactions. Nos. 14, 15, 16, Vol. VI. No. 1, Vol. VII. Proceedings. Part 6, Vol. VIII.

Essex.—The Essex Naturalist. Parts 10-18, 19-24, Vol. X. Parts 1-3, Vol. XI. *From the Essex Field Club.*

Edinburgh.—Royal Geological Society. Transactions. Part 4, Vol. VII. *From the Society.*

Edinburgh.—Royal Physical Society. Proceedings for the Session 1897-8. *From the Society.*

Glasgow.—Natural History Society. Part 2, Vol. V. *From the Society.*

Hamilton.—Mining Institute of Scotland. Transactions. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Hull.—Scientific and Field Naturalists' Club. Transactions. 1898. No. 1, Vol. I.

Lancashire Coalfield.—Elias Hall's Geological Sections. *Purchased.*

Leeds.—Philosophical and Literary Society. Annual Report.

Leeds.—Yorkshire Geological and Polytechnic Society. Transactions. Part 4, Vol. XIII. *From the Society.*

Leeds.—Yorkshire Ramblers' Club. Annual Report for 1897-8.

Leicester.—Literary and Philosophical Society. Transactions. Parts 1, 2, 3, 4, Vol. V., New Series. *From the Society.*

Liverpool.—Geological Society. Proceedings. Part 2, Vol. VIII.

Liverpool.—The Gypsum Boulder of Great Crosby, by T. M. Reade. *Presented by the Author.*

Liverpool.—Public Libraries and Art Galleries. 46th Annual Report, 1898.

London.—Applied Geology, by J. V. Elsder. Part II. *Presented by the Quary Publishing Co.*

London.—British Association for the Advancement of Science. Reports for 1897 and 1898. *From the Association.*

London.—British Museum. Types and figured specimens of Fossil Cephalopoda.

London.—Geological Magazine. (New Series.) Decade IV. Nos. 11 and 12, Vol. V. Nos. 1-9, Vol. VI. *Purchased.*

London.—Geological Society. Quarterly Journal. No. 216, Vol. LIV. Nos. 217, 218, 219, Vol. LV. *From the Society.*

London.—Geologists' Association. Proceedings. Part 10, Vol. XV. Parts 1, 2, 3, 4, Vol. XVI. *From the Association.*

London.—Institution of Mechanical Engineers. Proceedings. Nos. 1, 2, 3, 4, 1898. No. 1, 1899. *From the Institution.*

London.—Iron and Coal Trades' Review. Nos. 1600 to 1610, Vol. LVII. Nos. 1611 to 1635, Vol. LVIII. Nos. 1636 to 1648, Vol. LIX.

London.—Iron and Steel Institute. Journal. Vols. LIV. and LV. *From the Institute.*

London.—Palaeontographical Society. Vol. LII., for 1898. *Purchased.*

London.—Royal Society. Proceedings. Nos. 403 to 412, Vol. LXIV. Nos. 413 to 418, Vol. LXV. *From the Society.*

London.—The Colliery Guardian. Nos. 1975 to 1984, Vol. LXXVI. Nos. 1985 to 2009, Vol. LXXVII. Nos. 2010 to 2022, Vol. LXXVIII.

London.—The Mining Journal. Nos. 3297 to 3307, Vol. LXVIII. Nos. 3308 to 3344, Vol. LXIX.

Manchester.—Literary and Philosophical Society. Memoirs and Proceedings. Part 5, Vol. XLII. Parts 1 to 4, Vol. XLIII. *From the Society.*

Manchester.—Geographical Society. Journal. Nos. 7 to 12, Vol. XIV. *From the Society.*

Manchester.—The Owens College Museum. Report for the year 1898-9. Publications. Nos. 24, 25, 26, 27, 28. *From the College.*

Newcastle-upon-Tyne.—Institution of Mining Engineers. Transactions. Parts 5, 6, Vol. XV. Parts 1, 2, 3, 4, 5, 6, Vol. XVI. Nos. 1, 2, Vol. XVII.

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers. Transactions. Included in the Transactions of the Institution of Mining Engineers; also Annual Report for 1898, and "Account of the Strata of Northumberland and Durham." *From the Institution.*

Penzance.—Geological Society of Cornwall. Transactions. 85th Annual Report.

Rochdale.—Literary and Scientific Society. Annual Report for 1898.

Salford.—50th Annual Report of the Museum, Libraries, and Parks Committee, 1897-98.

Stafford.—North Staffordshire Field Club. Annual Report and Transactions for 1898-9. *From the Club.*

Stoke-on-Trent.—North Staffordshire Institute of Mining and Mechanical Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Truro.—Royal Institution of Cornwall. Journal. Part 4, Vol. XIII.

Wigan.—Science and Art of Mining. Nos. 5 to 26, Vol. IX. Nos. 1 to 3, Vol. X.

BOOKS, PAMPHLETS AND REPORTS.—ENGLISH AND FOREIGN.

Mineral Statistics of the Mines and Quarries. Parts 3 and 4, for 1897; Parts 1 and 2, 1898; also H.M. Inspector's Report of Mines and Quarries for S.W. District for 1897. London. *Presented by Joseph S. Martin.*

Mines and Quarries. Report for 1898 for the North Staffordshire District, by W. N. Atkinson. *Presented by the Author.*

A number of pamphlets relating to Geological subjects. *Presented by Mr W. Whitaker, F.R.S.*

Buried Bones about Liverpool, and the Elephant in Cheshire, by G. H. Morton, F.G.S. *Presented by the Author.*

On the Movements of Glaciers, by C. A. Lindvall, Stockholm. *Presented by the Author.*

Theory of the Earth, by J. Hutton. Vol. III., 1899. *Presented by W. Whitaker, F.G.S.*

Subsidence following Coal Workings, by S. R. Kaye. *Presented by L. B. Wells.*

Year Book of Scientific and Learned Societies for 1899. *Purchased.*

Description Géologique de la Montagne de Lure, by W. Kilian. 1886. *Presented by Mrs. Topley.*

Voyage Metallurgique en Angleterre par Dufrenoy, by De Beaumont. 1837. *Presented by Mrs. Topley.*

Critique sur la Discours de M. Dupont, Bruxelles. *Presented by E. van der Broeck.*

Eastern Margin of North Atlantic Basin. *Presented by W. H. Huddlestone, F.G.S.*

Life and Letters of Sir J. Prestwich, by his Wife. *Presented by the Publishers.*

Map of Canals and Navigable Rivers of England and Wales, by Lionel B. Wells. *Presented by the Author.*

Geological Survey of Great Britain.—Explanation of Horizontal Sections Nos. 25, 40 to 54, 57, 59, 60, 61, 63 to 72. *Presented by W. Whitaker, F.G.S.*

Reports of the State Geologist of New York for 1884 and 1886. *Presented by W. Whitaker, F.G.S.*

Guide to the Museum of Practical Geology, 3rd edition, 1867 *Presented by W. Whitaker, F.G.S.*

Earth Crust Movements and their Causes. J. Le Conte.

INDIA.

Calcutta.—Memoirs of the Geological Survey of India. No. 1. Vol. XXVIII.

Calcutta.—General Report of the Geological Survey of India. 1898-9. *From the Governor General in Council.*

Calcutta.—Geology of India. Pt. 1. Corundum (1898). *From the Geological Survey.*

AUSTRALIA.

Adelaide.—Royal Society of South Australia. Transactions. Part 2, Vol. XXII. *From the Society.*

Melbourne.—The Australian Mining Standard. Nos. 513 to 529, Vol. XIV.; Nos. 530 to 549, 551 to 555, Vol. XV.; Nos. 556, 558-9, 560-1-2, Vol. XVI. *From the Editor.*

Sydney.—Geological Survey of New South Wales: Department of Mines. Records. Parts 1, 2, Vol. VI. Mineral Resources. Nos. 3, 4, 5. Memoirs: Palæontology. No. 6. Ethnological Series. No. 1. *From the Hon. the Minister of Mines.*

Sydney.—Australian Museum. Report for 1896 and 1898.

Syney.—Australian Association for the Advancement of Science. Vol. VII. *From the Association.*

CANADA.

Halifax, N.S.—Nova Scotian Institute of Science. Proceedings and Transactions. Part 4, Vol. IX., 2nd Series. *From the Institute.*

Hamilton.—Hamilton Association. Journal and Proceedings for 1898. No. 14. *From the Association.*

Ottawa.—Federated Canadian Mining Institute. Proceedings for 1898.

Ottawa.—Canadian Mining Institute. Journal. Vols. I., II.

Ottawa.—Canadian Mining Review. Nos. 9, 10, 11, 12, Vol. XVII.; Nos. 1, 2, 3, 4, 5, 6, 7, 8, Vol. XVIII. *From the Editor.*

Ottawa.—Geological and Natural History Survey of Canada. Part 3, Vol. III. Annual Report. *From the Directory of the Survey.*

St. John, New Brunswick.—Natural History Society of New Brunswick. Bulletin 17. Part 2, Vol. IV. *From the Society.*

Toronto.—Canadian Institute. Proceeding. Part 6, Vol. I. (New Series); Part 7, Vol. II. *From the Institute.*

U.S. AMERICA.

Baltimore.—Maryland Geological Survey. Vol. II. *From the State Geologist.*

Cambridge.—Havard College. Bulletin of the Museum of Comparative Zoology. No. 9, Vol. XXXII; and Nos. 1, 2, Vol. XXXV.; also Vol. XXXIII. Annual Report of the Museum of Comparative Zoology for 1897-8. *From Alex. Agassiz.*

Chapel Hill, N. Carolina.—The Elisha Mitchell Scientific Society. Journal. Parts 1 and 2, Vol. XIV. 1898.

Chicago.—Field Columbian Museum. Annual Report for 1897-8. Geological Series. Nos. 3 to 6, Vol. I. Zoological Series. Nos. 11 to 15, Vol. I. *From the Museum.*

Chicago.—Academy of Sciences. Bulletin. No 2. And 40th Annual Report.

Denver.—Colorado Scientific Society. Proceedings. *From the Society.*

Houghton (Michigan).—Catalogue of the Michigan College of Mines. 1896-8.

Indiana.—Department of Geological and Natural Resources. Annual Report.

Indianopolis.—Mineral Resources. 22nd Report (1897).

Iowa.—Geological Survey of. Vol. VIII. *From the Director of the Survey.*

Jefferson City (Mo.)—Biennial Report of Bureau of Geology and Mines of Missouri for 1898.

Madison.—Wisconsin Geological and Natural History Survey. Bulletin. No. 1 and 2. *From the State.*

Minneapolis.—The American Geologist. Nos. 4, 5, 6, Vol. XXII.; Nos. 1, 2, 3, 4, 5, 6, Vol. XXIII.; Nos. 1, 2, 3, Vol. XXIV. *Purchased.*

New York.—The American Museum of Natural History. Bulletin. No. 1, Vol. X., and No. 1, Vol. XI.; also Annual Report for 1898. *From the Museum.*

New York.—American Institution of Mining Engineers. Transactions. 1898. Bulletin, No. 1, Vol. XXVII.

New York.—Stone. Nos. 1, 2, 3, 4, 5, 6, Vol. XVIII.; Nos. 1, 2, 3, Vol. XIX. *Presented by the Publisher.*

Philadelphia.—Franklin Institute. Journal. Nos. 4, 5, 6, Vol. CXLVI.; Nos. 1, 2, 3, 4, 5, Vol. CXLVII.; Nos. 1, 2, 3, Vol. CXLVIII. *From the Institute.*

Philadelphia.—Academy of Natural Sciences. Proceedings. Part 2, 1898; Parts 1, 3, 1899. *From the Academy.*

Philadelphia.—American Philosophical Society. Proceedings. Nos. 132 to 159, Vols. XXVIII. to XXXVIII.

Rochester.—Geological Society of America. Vol. IV. *Presented by Mr. W. Whitaker, F.R.S.*

Rock Island, Ill.—Mechanical Composition of Wind Deposits, by J. A. Udden. 1898. 69 pp. *Presented by the Augustana College.*

Scranton, Pa.—"Mines and Minerals." Nos. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Vol. XIX.; Nos. 1, 2, Vol. XX. *From the Editor.*

Washington.—Smithsonian Institute. Report of the U.S. State Museum, 1896.

Washington, U.S.—Geological Survey. Monographs XXIX., XXX., XXXI., XXXV. 18th Annual Report. Parts 1, 2, 3, 4, 5 for 1896-7. 19th Annual Report. Parts 6 and 6 continued. Parts 1, 4. Atlas to accompany Monograph XXXI. Bulletins 88, 89, 149.

FOREIGN.

Berlin.—Gesellschaft für Erdkunde: Zeitschrift, Nos. 4, 5, 6, Vol. XXXIII; Nos. 1, 2, Vol. XXXIV. Verhandlungen, Nos. 7, 8, 9, 10, Vol. XXV.; Parts 1, 2, 3, 4, 5, 6, Vol. XXVI. *From the Society.*

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft, Part 2, 3, 4, Vol. L.; No. 1, Vol. LI. *From the Society.*

Brussels.—Société Royale Malacologique de Belgique. Annales 1898-9, and Vol. XXXII., 1899. *From the Society.*

Buenos Ayres.—Museo Nacional. Communicaciones. Parts 2, 3, Vol. I. Annales No. 6.

Buenos Ayres.—Annuairis de la Direccion General dè Estadistica. Nos. 1, 2.

Caen.—Société Linnéenne de Normandie (5th Series), Vol. I. *From the Society.*

Dresden.—"8 Isis," July—December, 1896, January—June, 1898. *Presented by Naturwissenschaftliche Gesellschaft Isis.*

Freiburg.—Naturforschenden Gesellschaft, Berichte, 1899.

Görlitz.—Geognostische Beschreibung der Preussischen Oberlausitz (1857). *Presented by the Manchester Literary and Philosophical Society.*

Halle, A/S.—Kaiserliche Leopold. Carol. Deutsche Akademie. Parts 5, 17-21, Vol. LXI. Leopoldina, Nos. 33, 34 (1897).

Halle, A/S.—Vereins für Erdkunde, Mittheilungen. 1898 and 1899. *From the Society.*

Helsingfors.—Commission Géologique de la Finlande. Parts 7, 8, Vol. I. *From the Director.*

Helsingfors.—Geografiska Foreningen Finland. Vol. IV., 1897-8.

Iglo.—Jahrbuch des Ungarischen Karpathen-Vereines. No. XXV., XXVI.

Kazan (Russia.—La Société des Naturalistes de l'Université. Nos. 2-6, Vol. XXX.; Nos. 1-6, Vol. XXXI.; Nos. 1-3, Vol. XXXII.

Lausanne.—Société Vaudoise. Bulletins, 129, 130, 131, Vol. XXXIV.

Lille.—Société Géologique du Nord. Annales, Vol. XXVI., 1897.

Mexico.—Sociedad Científica "Antonio Alzate." Memorias Y. Revista. Nos. 9, 10, 11, 12, Vol. XI.; Nos. 1, 2, 3, 4, 5, 6, 7, 8, Vol. XII. Bibliographica Geologica y Minera de la Republica Mexicana.

Madrid.—Boletin del Ayuntamients de Madrid. No. 97, Vol. II.

Montevideo.—Annales del Museo Nacional. Nos. 10, 11, Vol. III.

Naples.—Rendiconti dell' Accademia della Scienze Fisiche e Mathematiche. No. 12, 3rd Series, Vol. IV.; Parts 1, 2, 3, 4, 5, 6, 7, Vol. V. *From the Academy.*

Paris.—Société de Spéléogique. "Spelunca." Nos. 13, 14, 15, Vol. IV. *From the Society.*

Paris.—Sociéte Géologique de France. Bulletin. Vol. XXV., and Nos. 1-5, Vol. XXVI.

Pisa.—Società Toscana di Scienze Naturali. Memoirs, Vol. XVI. Atti, Vol. XI.

Rome.—Atti della Reale Accademia dei Lincei. Rendiconti. Nos. 10, 11, Vol. VII.; Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Vol. VIII.; Nos. 1, 5, 2nd Series, Vol. VIII. *From the Academy.*

St. Petersburg.—Comité Geologique. Bulletin. Nos. 4, 5-10, Vol. XVII.; Nos. 1, 2, Vol. XVIII.; also Supplement to Vol. XVI. Memoirs. No. 1, Vol. XVI.; No. 4, Vol. VIII.; No. 3, Vol. XII. *From the Society.*

St. Petersburg.—Section Géologique du Cabinet de sa Majesté. Part 3, Vol. II.; Part 1, Vol. III.

St. Petersburg.—Russ. Kaiser Mineralog. Gesellschaft. Verhandlungen. No. 1, Vol. XXXVI.

St. Petersburg.—L'Académie Impériale des Sciences. Bulletin. V. Series, Nos 2, 3, 4, 5, Vol. V; Nos. 4, 5, Vol. VI.; No. 1, Vol. VII. Memoirs. No. 2, Vol IV.; No. 2, Vol. VI. *From the Academy.*

Stockholm.—Académie Royale Suédoise des Sciences. Series 2, Vol. XXIV.

Tokyo (Japan).—Journal of the College of Science of the Imperial University of Tokyo. Part 2, Vol. XI.

Upsala.—Geological Institution of Upsala. Bulletin. No. 7, Vol. IV.

SOCIETIES WITH WHICH THE SOCIETY EXCHANGES ITS TRANSACTIONS, AND INSTITUTIONS AND JOURNALS TO WHICH A COPY IS SENT FREE.

I—ENGLAND.

London .....British Association for the Advancement of Science, Burlington House, London.
British Museum, The Superintendent, Copyright Office.
British Museum Library, Natural History Department, Cromwell Road, Kensington.
Geological Society, Burlington House, W.
Geological Survey, Jermyn Street, S.W.
Geologists' Association, University College, Gower Street, W.C.
Institution of Mechanical Engineers, Storey's Gate, St. James' Park, Westminster, S.W.
Iron and Steel Institute, 28, Victoria Street, S.W.
Royal Institution of Great Britain, Abemarle Street.
Royal Society, Burlington House, W.
Public Library, Kensington, High Street, W.

Manchester .....The Manchester Association of Engineers, Grand Hotel, Aytoun Street.
Field Naturalists' Society.
Free Library, King Street.
Literary and Philosophical Society, 36, George Street.
Manchester Geographical Society, 16, St. Mary's Parsonage.
The Owens College.
Salford Royal Museum and Library.

Barnsley.....Midland Institute of Mining Engineers.

Birmingham ....Free Library and Museum.
South Staffordshire and East Worcestershire Institute of Mining Engineers, Colmore Chambers, 3, Newhall Street.

Bradford .....Public Free Library, Bradford, Yorkshire.

Bristol .....Naturalists' Society, Clifton.

Cambridge .....Geological Museum, University.
University Library.

Cardiff .....Cardiff Naturalists' Society, 44, Loudoun Square.
South Wales Institute of Mining and Mechanical Engineers, Park Place, Cardiff.

Chester .....Society of Natural Science, Grosvenor Museum.

Chesterfield.....Chesterfield and Midland Counties Institution of Engineers (G. A. Lewis, Secretary, Albert Street, Derby).

Cornwall .....Royal Geological Society, Penzance.
Royal Institution, Truro.
Mining Association and Institute of Cornwall, Tuckingmill, Camborne.

Essex .....Essex Field Club—to 31st March, 1900—9, Woodgrange Road, Forestgate, Essex—after that—Passmore-Edwards Museum, Romford Road, Stratford, Essex.

Exeter .....Albert Memorial Museum.

Leeds .....Philosophical and Literary Society.
Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Hon. Librarian, 259, Hyde Park Road, Leeds).
Geological Association, Mechanics' Institution, Cookridge Street.

Leicester.....Literary and Philosophical Society.

Liverpool .....Free Library and Museum.
Geological Association, Free Library, William Brown Street.
Geological Society, Royal Institution.
Science Students' Association, Royal Institution, Colquitt Street.

Mirfield .....Yorkshire Geological and Polytechnic Society, Hopton, Mirfield.

Newcastle-on-Tyne Institution of Mining Engineers.
North of England Institute of Mining and Mechanical Engineers.

Newcastle-under-Lyme ..... North Staffordshire Naturalists' Field Club, (W. Wells Bladen, Esq., Stone, Staffordshire).

Norwich ..... Norfolk and Norwich Naturalists' Society.

Oxford ..... Bodleian Library.
Radcliffe Library.

North Shields .... Public Free Library.

Rochdale ..... Literary and Scientific Society, 105, Freehold Street.

Southampton .... Hampshire Field Club, Harley Institution.

Stoke-on-Trent .. North Staffordshire Institute of Mining and Mechanical Engineers.

Warwick ..... Natural History Society.

Watford, Herts .. Hertfordshire Natural History Society and Field Club, the Public Library, Watford. (Daniel Hill, Esq., Hon. Librarian, Herga, Watford, Herts).

Wigan ..... Free Library.
Mining School.

II.—Scotland.

Dundee ..... Free Library and Museum.

Edinburgh ..... Advocates' Library.
Edinburgh Geological Society.
Royal Society.
Royal Physical Society.

Glasgow ..... Geological Society.
Natural History Society.

Hamilton ..... Mining Institute of Scotland.

III.—Ireland.

Dublin .....Royal Dublin Society.
The Library, Trinity College.

Belfast .....Natural History Society, the Museum.

IV.—Australia.

Adelaide.....Royal Society of South Australia (W. C. Rigby, 74, King William Street, Adelaide).

Melbourne .....Geological Society of Australasia, 17A, Queen Street.
Public Library of Victoria.
Australian Association for the advancement of Science.
Australian Mining Standard, Monahan's Buildings, 231-3, Little Flinders Street

Sydney .....Free Public Library.
Royal Society of New South Wales, 37, Elizabeth Street.
Department of Mines.—The Honourable the Minister of Mines.

V.—Canada.

Halifax, Nova Scotia..... } Nova Scotian Institute of Science.

Hamilton, Ont. ..Hamilton Association.

Montreal.....Library of Canadian Mining Institute, Room 4, Windsor Hotel, Montreal.
M'Gill University (Principal, Sir J. W. Dawson, F.G.S.).

Ottawa .....Geological Survey of Canada (G. M. Dawson, C.M.G., LL.D., F.R.S., Director, Museum, Sussex Street, Ottawa).

St. John, N.B. ..Natural History Society of New Brunswick.

Toronto .....Canadian Institute, 58, Richmond Street, E.

VI.—India.

Calcutta.....Geological Survey of India.

VII.—UNITED STATES.

Baltimore .....The Maryland Geological Survey (The State Geologist, John Hopkins University).

Boston .....Free Library.

Chapel Hill, North Carolina ..... } The Elisha Mitchell Scientific Society.

Columbus .....Ohio, Geological Survey of. (The State Geologist).

Denver .....Colorado Scientific Society, Denver, Colorado.

Indiana .....Department of Geology and Natural Resources (W. S. Blatchley, Esq., State Geologist).

Illinois .....Illinois Mining Institute, Springfield, Ill.
Field Columbian Museum, Chicago.

Michigan .....Michigan Mining School, Houghton.

Jefferson City, Missouri .... } Missouri Geological Survey.

New York .....American Institute of Mining Engineers (R. W. Raymond, 99, John Street, New York City).
American Museum of Natural History, Central Park.

Philadelphia ....Academy of Natural Sciences.
Franklin Institute.
Pennsylvania Geological Survey.
American Philosophical Society, 104, S. Fifth Street.

Scranton, Pa. ..Editor of "Mines and Minerals."

Washington ....Department of the Interior. U.S. Geological Survey.
Smithsonian Institute.

Wisconsin .....Wisconsin Academy of Science, Arts, and Letters, Madison.

Wyoming .....Historical and Geological Society.

VIII.—FOREIGN SOCIETIES.

Berlin.....Deutsche Geologische Gesellschaft.
Gesellschaft für Erdkunde. Wilhelmstrasse, 23, S.W.

Brussels .....Société Royale Malacologique de Belgique.

Buenos Ayres....Officiana Nacional de Commercie

Lille .....Société Geologique du Nord.

Christiania.....Royal University of Norway.

Dresden .....Naturwissenschaftliche Gesellschaft Isis.

Halle, A/S. ....Verein für Erdkunde.
Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.

Helsingfors.....La Commission Gèologique de la Finlande. Dr. J. J. Sederholm, Boulevardsgatan 29.

Iglo, Hungary ..Societé Hongroise de Carpatha.

Kazan, Russia ..La Société des Naturalistes de l'Université de Kazan.

Kieff, Russia ....La Société des Naturalistes.

Lausanne (*Suisse*).Société Vaudoise des Sciences Naturelles.

Mexico .....Sociedad Cientifica "Antonio Alzate."

Naples .....Accademia della Scienza Fisiche e Mathematiche.

Paris .....La Société Gèologique de France.

Pisa .....Società Toscana di Scienze Naturali, Museo di Storia-Naturale.

Rio de Janeiro ..Museo Nacional.

Rome .....Reale Academia dei Lincei.

St. Petersburg ..Académie Impériale des Sciences.
Institut des Mines. Comité Géologique.

Turin .....Acadêmie Royale des Sciences.

IX.—Scientific Journals, &c.

Iron and Coal Trades Review, 165, Strand, W.C.

Mining Journal, 446, Queen Victoria Street, London.

Colliery Guardian, 49, Essex Street, Strand, London.

Science and Art of Mining, 27, Wallgate, Wigan.

LIST OF MEMBERS.

NOVEMBER, 1899.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	Names and Addresses.
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1884	Ainsworth, John, Colliery Offices, Walkden, Bolton.
1884	Aldred, James, Bull Hotel, Ratcliffe.
1897	Allen, Edward, M.E., Willow Bank, Peel Causeway, Bowdon, Cheshire.
1898	Allen, Robert, 46, Norah Street, Lower Broughton, Manchester.
1879	Arrandale, John Thomas, 82, Brook House Street, Wigan.
1893	Ashworth, John, C.E., 8, King Street, Manchester.
1878	Ashworth, Thomas, 42, Deansgate, Manchester.
1877	Atherton, James, 13, Mawdsley Street, Bolton. *Member of Council.*
1895	Atherton, H. Stanley.
1878	Atkinson, W. N., H.M. Inspector of Mines, Barlaston, Stoke-on-Trent.
1897	Baker, Godfrey, Pendlebury, Manchester.
1893	Bancroft, Robert E,, 8, St. James' Square, Manchester.
1895	Barnes, J., F.G.S., South Cliff House, 301, Great Clowes Street, Higher Broughton. *Member of Council. Hon. Auditor.*
1875	Barrett, W. S., J.P., 64, The Albany, Old Hall Street, Liverpool. *President.*
1891	*Bell, Thomas*, J.P., 15, The Valley, Scarborough.
1897	Bennett, F. F., M.I.E.E., 13, Victoria Buildings, Manchester.

Year of Election.	Names and Addresses.
1881	Black, W. G., F.R.C.S. Ed., F.G.S. Ed., 2, George's Square, Edinburgh.
1898	Boden, Peter, Butterworth Hall Colliery, Milnrow, Rochdale.
1889	Bolton, Edgar O., Burnley Collieries, Burnley.
1867	Bolton, H. H., Newchurch in Rossendale, near Manchester.
1880	Bolton, H. H., jun., The Collieries, Accrington.
1894	Borrows, William, Engineer, Providence Foundry, St. Helens.
1878	Bramall, Ernest, E., Pendlebury Collieries, near Manchester.
1886	Bramall, Henry, M.Inst.C.E., Shade House, Pendlebury, Manchester.
1895	Brierley, Brandon T., F.G.S., Bellayre, Lymm, Cheshire.
1878	Brocklehurst, Thomas, Rumworth Colliery, Dean, Bolton.
1877	*Broeck, Ernest Van den*, 32, Place de l'Industrie, Brussels.
1897	Brooks, The Hon. William, J.P., Crawshaw Hall, Rawtenstall, Manchester.
1881	Brynam, William, Douglas Bank Colliery, Wigan.
1878	Burrows, John S., F.G.S., Green Hall, Atherton, near Manchester. *Past-President.*
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1897	Caldwell, J. S., Westhoughton, Bolton.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1898	Clark, Geo. F., Bickershaw Collieries, Leigh, Lancashire.
1894	Clarke, Robert, 42, Deansgate, Manchester.
1894	Cole, Robert H., Endon, Stoke-on-Trent.
1895	Coope, Samuel, Land and Mine Surveyor, Farnworth, Bolton.
1878	Cowburn, Henry, 253, Westleigh Lane, Westleigh, near Manchester.
1883	Crankshaw, Joseph, F.G.S., Montcliffe, Horwich. *Member of Council.*
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1862	Cross, John, 77, King Street, Manchester.

Year of Election.	Names and Addresses.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S., F.S.A., The Owens' College, Manchester. *Past-President.*
1877	*De Rance, C. E.*, F.G.S., 32, Carshalton Road, Blackpool.
1898	Dickinson, Archibald, Bank Hall Colliery, Burnley.
1856	Dickinson, Joseph, F.G.S., South Bank, Sandy Lane, Pendleton. *Past-President. Trustee.*
1889	Dobbs, Joseph, Coolbawn, Castlecomer, Co. Kilkenny.
1898	Douglas, Ernest, Pemberton Collieries, Wigan.
1899	Downham, William, F.G.S., 65, Grenville Street, Stockport.
1898	*Eagle, George, Winter's Buildings, 32, St. Ann's Street, Manchester.
1878	Ellesmere, the Right Hon. the Earl of, Worsley.
1895	Ellis, Thomas Ratcliffe, Solicitor, King Street, Wigan.
1897	Ellis, W. F. Wood, M.Inst.M.E., M.S.A., 5, John Dalton Street, Manchester.
1884	Else, George, Altham Colliery, Whalley Road, Accrington.
1895	Evans, Robert, Mining Engineer, Royton, Oldham.
1897	Evans, Walter, J.P., M.E., Royton, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1891	Finch, John, Hamstead Colliery, Great Barr, Birmingham.
1891	Fletcher, Arthur, Outwood Collieries, Radcliffe.
1896	Fletcher, Leonard R., Atherton Collieries, Atherton, Manchester.
1868	Fletcher, Thomas, Wheatfield, Bolton-le-Moors.
1873	Garforth, W. E., F.G.S., Halesfield, Normanton.
1893	Garside, Edward, B.Sc., Town Hall Chambers, Ashton-under-Lyne.
1874	*Geikie, Sir Archibald*, D.Sc., LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.

Year of Election.	Names and Addresses.
1892	Gerrard, John, H.M. Inspector of Mines, Worsley. *Member of Council.*
1882	Glover, B. B., 41A, Victoria Buildings, Manchester.
1898	Glover, J. W., M.E., 41A, Victoria Buildings, Manchester.
1899	Goodwin, John, Flattocks, Castleton, near Manchester.
1892	Grant, Frederick John, Bank Field, Burnley.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1863	Greenwell, G. C., F.G.S., M.I.C.E., Elm Tree Lodge, Duffield, Derby. *Past-President.*
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport. *Member of Council.*
1879	Greenwood, John, c/o The Globe Spinning Company, 1, Marsden Street, Manchester.
1892	Gregson, G. Ernest, 11, Chapel Street, Preston.
1890	Gresley, W. S., F.G.S., F.G.S.A., 348, West 8th Street, Erie, Pennsylvania, U.S.A.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1888	Grundy, James, Inspector of Mines in India, 27, Chowringhee Road, Calcutta, India.
1897	Guy, J. G.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot, *Past-President.*
1898	*Hall, Levi J., Morland House, Birch Vale, near Stockport. (Furness Vale Collieries, Stockport.)
1897	Hall, William, B.Sc., Science Teacher, 44, Arrowsmith Terrace, Bolton.
1887	Hallas, George H., Mining Engineer, Huyton, near Liverpool.
1899	Hampson, Joshua, 31, Bellott Street, Cheetham, Manchester.
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1897	Harris, George E., M.E., Assam Railway and Trading Co., Limited, Margerita, Assam, India.

Year of Election.	Names and Addresses.
1894	Harrison, George B., H.M. Inspector of Mines, 278, Worsley Road, Swinton, Manchester. *Member of Council.*
1892	*Haworth, Denis, Beech House, Blackburn Road, Accrington.
1894	Hayward John, Ladyshore Colliery, Little Lever, Bolton.
1897	Heather, Frank, 35, Dickinson Street, Manchester.
1889	Higson, Charles H., 106, Eccles Old Road, Pendleton, Manchester.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1897	Hobson, Bernard, M.Sc., F.G.S., The Owens College, Manchester.
1877	Holding, William, Cossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., 37, Cross Street, Manchester. *Vice-President. Hon. Treasurer.*
1899	Hollingworth, David, 29, Cumberland Street, Lower Broughton.
1895	Holroyd, W. F., F.G.S., River Cottage, Lower Broughton. *Vice-President.*
1897	Howsin, Evelin G., Huntroyd Estate Office, Padiham.
1884	Hughes, Owen, Hindley, near Wigan.
1874	*Hull, Professor Edward*, M.A., F.R.S., 20, Arundel Gardens, Notting Hill, London, W.
1895	Hutchinson, John William, Bamfurlong Collieries, Wigan.
1887	Jackson, Andrew, Manager, Collins Green and Bold Collieries, Newton-le-Willows.
1878	Jackson, Charles G., Rookwood, near Chorley.
1898	James, Isaac, Wigan Junction Collieries, Abram, Wigan.
1883	Jobling, Albert, 91, Rectory Road, Burnley.
1883	Jobling, Henry, 91, Rectory Road, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1832	Johnson, William, Abram Colliery, Wigan.

Year of Election.	Names and Addresses.
1887	Kay-Shuttleworth, Sir Ughtred J., Bart., M.P., Gawthorpe Hall, Burnley. *Past-President.*
1897	Keen, James, Hindley Green, Wigan.
1894	Kelsall, James E.
1893	Kenrick, James P., 8, St. James's Square, Manchester.
1879	*Kinahan, G. H.*, M.R.I.A., Woodlands, Fairview, Co. Dublin.
1889	Knowles, John, Brynn Mount, Westwood, Lower Ince, Wigan.
1887	*Knowles, Lees, M A., LL.M., M.P., Westwood, Pendlebury. *Trustee.*
1898	Krauss, John Samuel, B.A., Whitecot, Wilmslow, Cheshire.
1898	Landless, Richard, Bank Hall Colliery, Burnley.
1898	Laverick, John H. W., Pye Hill House, Alfreton, Derbyshire.
1890	Law, J. Illingworth, Waterfoot, near Manchester.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.
1897	Lees, Frederick, The Rookery, Ashford, Bakewell.
1899	Leigh, Oswald B., Stoneleigh, St. Anne's-on-Sea.
1894	Lindsey, Charles R., B.Sc., 509, Edge Lane, Droylsden, Manchester. *Member of Council.*
1898	Livesey, John, 117, Stoneclough Road, Stoneclough, Manchester.
1898	Lomax, James, 65, Starcliffe Street, Moses Gate, Bolton.
1877	Lord, James, Hill House, Rochdale.
1898	Lowe, Henry, Bower Colliery, Hollinwood, near Oldham.
1881	Macalpine, G. W., Parkside, Accrington.
1897	McCallam, Theo. S., C.E., 4, Chapel Walks, Manchester.
1890	McGeever, James, Garswood Hall Colliery, Wigan.
1897	Makepeace, H. R., H.M Inspector of Mines, Trentham, Stoke-on-Trent.
1891	Marshall, Herbert S., The Larches, Wigan.

Year of Election.	Names and Addresses.
1892	Mathews, D. H. F., H.M Inspector of Mines, Hoole, Chester. *Member of Council.*
1893	Matthews, E. L., Imperial Iron Works, West Gorton, Manchester.
1896	Matthews, Thomas, Artesian Engineer, West Gorton, Manchester.
1873	*Martin, Joseph S.*, H.M. Inspector of Mines, The Vikings, 16, Durdham Park, Clifton, Bristol.
1892	Miller, Arthur, Broad Oak, Hurst, Ashton-under-Lyne.
1892	Millington, W. W., Hardman House, Hollinwood, Oldham.
1892	Mills, David, Bradford Street, Farnworth.
1895	Mitton, A. Dury, Oakwood, Walkden, Bolton. *Member of Council.*
1895	Mort, Arthur, B.Sc., Curran House, Dungannon, Co. Tyrone, Ireland.
1874	*Morton, G. H.*, F.G.S., 209, Edge Lane, Liverpool.
1878	Nall, Simon, Newbold, Rochdale.
1898	Naylor, Alfred, Cotes Park Colliery, Alfreton, Derbyshire.
1897	Nelson, William, jun., Clifton and Kearsley Collieries, Clifton, Manchester.
1897	Noar, L. Lamb, The Grove, Lymm.
1888	Oliver, Samuel A.. King Street, Wigan.
1891	Orchard, Albert J. A., Whitehouse, Nailstown Colliery, near Leicester.
1876	Peace, George, Monton Grange, Eccles. *Vice-President.*
1883	Peace, George Henry, M.Inst.C.E., Monton Grange, Eccles.
1897	Pearce, Charles H., 100, Park Road, Bolton.
1897	*Pickup, P. W. D., Rishton Colliery, Rishton, nr. Blackburn.
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*

Year of Election.	Names and Addresses.
1899	Pilkington, Lawrence, South Garth, Eccles Old Road, Pendleton.
1877	Place, W. H., Hoddleston Collieries, Darwen.
1887	Platt, Samuel Sydney, M.Inst.C.E., F.G.S., Moss House, Kings Road, Rochdale. *Vice-President.*
1891	Prestwich, Joseph, Elm Bank, 72, Eccles Old Road, Pendleton, Manchester.
1897	Reid, Alexander, Dover Collieries, Dover.
1897	Richardson, Isaiah, Blainscough Collieries, Coppull, near Chorley.
1860	Ridyard, John, F.G.S., Hilton, Bank, Little Hulton, Bolton. *Past-President*
1893	Rigby, John, Highfield, Winsford, Cheshire.
1897	Ritson, W. A., Crumpsall, Manchester.
1889	Robinson, John, Haydock Collieries, St. Helens.
1892	Roscoe, George, Peel Hall Collieries, Little Hulton, Bolton.
1898	Roscoe, Thomas, Peel Hall Collieries, Little Hulton, Bolton.
1895	Rothwell, Samuel, Silverwell Street, Bolton.
1895	Ryans, Joseph, Colliery Manager, Arigna Mines, Carrick-on-Shannon.
1887	Saint, William, H.M. Inspector of Mines, Kersal Bank Higher Broughton, Manchester. *Past-President. Hon Secretary.*
1888	Scarborough, George Edward, Colliery Manager, Newton and Meadows Collieries, Wigan.
1897	Scholes, Thomas, 25, Crossley Street, Longsight, Oldham.
1887	Scott, Frederick W., Atlas Works, Reddish, near Stockport.
1889	Scott, William B., 133, Manchester Old Road, Middleton.
1891	Scowcroft, Thomas, Redthorpe, Bromley Cross, near Bolton. *Member of Council.*
1899	Selby, John B., Atherton House, Leigh, Lancashire.

Year of Election.	Names and Addresses.
1882	Settle Joel, The Hill, Alsager, Stoke-on-Trent.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1889	Settle William, Brunswick House, Haulgh, Bolton.
1899	Shaw, Alfred, Bersham Colliery, Wrexham.
1884	Shaw, David, Norbury Moor, near Stockport.
1884	*Simpson, W. W., Winkley, near Whalley, Blackburn.
1894	Slee, John, Engineer, Earlestown.
1864	*Smethurst, William, F.G.S., Brynmair, Dolgelly, N. Wales.
1881	Smith, John, Bickershaw Collieries, Westleigh, near Manchester.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney Arthur, 1, Princess Street, Albert Square, Manchester.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire.
1881	Squire, J. R., Assoc.M.Inst C.E., Thrale Hall, Streatham, Surrey.
1890	Stafford, Thomas, King's Drive, Heaton Moor, near Stockport.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon. *Past-President. Hon. Librarian.*
1882	Stopford, T. R., Ashton's Green Collieries, St. Helens, Lancashire.
1891	Sutcliffe, Richard, Horbury, near Wakefield.
1899	Tansley, Springfield House, Coppull, Chorley.
1889	Taylor, William, 51 Park Road, Darwen.
1892	Thom, John, Canal Works, Patricroft.
1893	Thompson, F. W., 18, Wood Street, Bolton.
1892	Thompson, James, 248, Chorley Road, Westhoughton, Bolton.
1897	Tickle, James, Abram Collieries, Bickershaw, Wigan.

Year of Election.	Names and Addresses.
1893	Timmins, Arthur, A.M.I.C.E., F.G.S., Bridgewater Foundry, Runcorn.
1891	Tonge, Alfred J., Hulton Colliery, near Bolton.
1873	Tonge, James, F.G.S., Assoc.M.Inst.C.E., Albany Chambers. Mawdsley Street, Bolton. *Past-President.*
1898	Tonge, James, Jun., F.G.S., 21, Mawdsley Street, Bolton. *Hon. Secretary.*
1886	*Trafford, Sir Humphrey Francis de, Bart., 18, Arlington Street, London, W.
1895	Travers, T. W., Mining Engineer, Church Street, Leigh, Lancashire.
1892	Turner, William, Wigan Junction Colliery, Abram, near Wigan.
1896	Turner, William, Sherdley Collieries, St. Helens.
1876	Unsworth, John, Scott Lane Collieries, Wigan. *Member of Council.*
1887	Walkden, Richard, Colliery Manager, 26, Watery Lane Terrace, Springvale, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1893	Wallwork, Jesse, Shakerley Collieries, Tyldesley, near Manchester.
1888	*Walmesley, Oswald, 2, Stone Buildings, Lincoln's Inn, London.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1897	Walton, Thomas, Habergham Colliery, Burnley.
1892	Ward, Alexander Haustonne, Ranigunj, Bengal, India.
1885	Ward, Thomas, J.P., F.G.S., Brookfield House, Northwich.
1880	Watts, William, F.G.S., 34, Wilkinson Street, Sheffield. *Past-President.*

Year of Election.	Names and Addresses.
1897	Wells, Lionel B., M.Inst.C.E., 5, John Dalton Street, Manchester. *Member of Council.*
1877	West, T. E., Union Street, Oldham.
1890	*Whitaker, William*, B.A., F.R.S., F.G.S., Freda, Camden Road, Croydon.
1891	Whitehead, J. J., Bracklyn, Steven Street, Stretford, Manchester.
1898	Widdowson, J. H., 19, Brazenose Street, Manchester.
1867	*Wild, George*, Albert Street, Bardsley, Ashton-under-Lyne.
1880	Williams, Sir. E. Leader, M.Inst.C.E., Manchester Ship Canal Company, King Street, Manchester.
1897	Winstanley George H., F.G.S., 42, Deansgate, Manchester. *Hon. Auditor.*
1876	Winstanley, Robert, C.E., 42, Deansgate, Manchester. *Past-President.*
1886	*Wood, Guy.
1897	Wood, John, M.E., Barley Brook Foundry, Wigan.
1897	Wood, Percy Lee, Newtown Collieries, Clifton, Manchester.
1898	Woodeson, W., 57, Roseneath Road, Urmston.
1876	Woodward, H. A.
1895	Wordsworth, T. H., New Moss Colliery, Audenshaw, near Manchester.

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Members are requested to communicate to the Hon. Secretaries all changes of address, also any omissions, or corrections required in the list.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XI. VOL. XXVI. SESSION 1899-1900.

MEETING AT OWENS COLLEGE.

A SPECIAL MEETING of the Members was held, by permission, on Friday, November 10th, 1899, at the Owens College, in conjunction with the Manchester Field Club.

Professor BOYD DAWKINS, M.A., F.R.S., F.G.S., in the Chair.

ON SUB-OCEANIC TERRACES AND RIVER VALLEYS OFF THE COASTS OF THE BRITISH ISLES AND WESTERN EUROPE.

By Professor EDWARD HULL, M.A., LL.D., F.R.S., F.G.S.

Our American cousins, the geologists and physicists, not satisfied with investigating the phenomena of their own vast and magnificent country, have turned their attention to the ocean which bounds it, with a view to determining the nature of the forms and features of the sub-Atlantic and sub-Pacific floors, and the results that they have arrived at are of so remarkable, I might say so startling, a character, that when I read them in the publications, particularly those of Professor J. W Spencer, I was so struck with their interest and novelty, and the great problems in physical geography and change of level that they present, that I determined humbly,

but with perseverance, to ascertain whether on the Eastern side of the Atlantic similar features under the ocean were presented to those which the American geologists had found on the Western side of the Atlantic. Now, what were the main features that were discovered by means of the soundings along the shores of North America, extending southwards to past the Equator into South America and through the West Indian islands? In the first place, it was found that from the margin of the land there extended out to a greater or less distance a sloping, shelving platform, breaking off in a steep descent, and then succeeded by another platform that in its turn was broken off by a steep descent or escarpment leading down to the margin of the abysmal regions of the ocean, at a depth of 1,200 or 1,500 fathoms. And not only so, but these platforms and the steep escarpments by which they were bounded were found to be traversed by deep channels cutting not only through the platforms, but down to the very base of the lowest platform to where it opens out on the floor of the abysmal ocean. And it was also found that some of these channels were almost physically connected with the rivers coming down into the ocean at various points—that one river entered the ocean and then was found to be represented by a channel cutting down to a depth of 1,200 or 1,500 fathoms below the surface. What could these channels be but the old river valleys before the whole region was submerged to the extent it is now? So interesting was this subject, as I have said, that I determined to investigate whether we had representations of these features along the coasts of the British Islands and Western Europe. Now, what was the process by which we are able to ascertain the form of the ocean bed? We are all familiar with maps on which the hills and valleys are represented by contour lines —lines traced at successive elevations, say one of 100 feet,

another of 200 feet, another of 300 feet, and so on up to a thousand feet or more, and by tracing out these lines through a hilly and mountainous country you can restore the physical features with the greatest precision, and sometimes with great beauty, as in the case of the Cuchullin Hills in the West of Scotland. Then, in a similar manner we can restore the bed of the ocean. We take the Admiralty charts, which, I am happy to say, throughout this region of the British Islands, the Bay of Biscay and the coast of Portugal, have a great number of accurately determined soundings, and you begin with your pencil to trace out the contour lines, or isobathic lines, of equal depths. Take the line, say, of 100 fathoms: you can trace that out by means of soundings, step by step, along the whole coast; you take others of greater depth, down to 1,200 fathoms, and although the soundings become somewhat fewer as you go out to those great depths, yet they are quite sufficient, with the aid of those that are nearer the land, and at less depths, to enable you to determine with great accuracy the form of the ocean bed. Now, what are the features which we find in tracing these isobathic lines? First, we have what has been long recognised as the British platform; a platform sloping out from the coast down to the level of about 100 fathoms, opposite the West Coast of Scotland, generally following, in a rude manner, the contour of the Western Islands themselves, but gradually deepening until when you come to the edge of the Bay of Biscay it has gone down—that is, the margin of the platform—to a depth of 200 fathoms, and that depth of 200 fathoms is the accurate edge of the Continental platform all the way to the Straits of Gibraltar. Now, this platform is a sloping plain—sloping at the average rate about six feet per mile, so when you get to the margin of it you get to the level of the 100 or 200-fathom contour, about 600 to 1200 feet, and it is perfectly continuous all

the way to Gibraltar, and probably further. It is represented here (referring to the map) by this 200-fathom contour, running continuously all the way down to the Straits of Gibraltar. Now, that platform has long been recognised. It is no novelty on my part, except that I have been able to trace it with greater accuracy than you will find it on ordinary maps, because I have traced it step by step by means of these contours. Now, this platform is terminated by a very remarkable feature, represented in these Admiralty charts by a coloured band. The region to which I am now alluding extends, at least as far as I have worked it, from the West of Scotland—from the Rockall Islands—all the way down to the Straits of Gibraltar, a distance of about 1,200 miles. This platform, as I have said, is terminated along what I at first called "the great escarpment"—because it is often in the form of an escarpment—but, as some of my geological critics took exception to the term "escarpment," I very unwisely, I think, gave in, and called it "the great declivity." I do not care by what name you call it; the thing is there. Of course in some places it is steeper than in others; but when you find in this neighbourhood, where the base of the escarpment is at the depth of 1200 fathoms, its contour is in close proximity with the top of the escarpment at the edge of the platform, at a depth of only 200 fathoms, you can imagine what a tremendous descent there is in that space. It is equal to a descent of 6000 feet. I think there are many cases where the escarpment is equally steep—as in the Bay of Biscay. But at any rate this grand declivity, or escarpment, is a most remarkable feature. We have nothing like it in Europe, and the only similar physical feature which is to be found that I am aware of, is the great escarpment on the coast that overlooks the Gulf of Mexico, and extends into the United States. There you have a similar feature

extending to 1500 or 1600 miles into the Southern States of America. Then, from the base of this escarpment, which descends at various angles to the 1200 fathom contour, on the West Coast of Scotland—gradually increasing its depth until in the Bay of Biscay it reaches sometimes the 1500 fathoms contour—it gives place to the great abysmal plain of the Ocean, covered with the Globigerina ooze. Now of what is this platform composed? You will at once understand that it is covered to a greater on less depth with detrital matters, sands, gravels, shells, &c., which have been worn down along the cliffs of the adjoining coast, and spread over the floor of the sloping plain by the tidal and other currents; so, if there were channels originally traversing that plain, the probabilities are that you will find them silted up to a greater on less extent. Therefore it is a very remarkable thing, that in spite of this silting which must have taken place to so great an extent through thousands of years you find the remains of what I am going to describe as old river channels traversing the platform. The base of this grand escarpment was formerly the margin of the Atlantic Ocean and this whole region with its widespread table land—as it was then—and this grand escarpment, or declivity, represents ancient Europe at not a very distant Geological period. There is no reason at all, so far as can be seen, why this should not have been the margin of an ancient land, where the Atlantic breakers once dashed against gigantic cliffs several thousand feet in height. But when I come to describe the most interesting feature, that is to say the old river channels crossing the platform, connected in some cases either inferentially with existing streams, or actually so, as in the case of the Adour, and cutting down through the platform to the very base of the 1500 fathom contour, I think you will admit that the case is absolutely incontestable.

Now I must ask you to suppose, in the first place, that this platform was land. That is no great demand upon your imagination because it only involves the idea of a rising of 600 or 1000 feet. But when this region of the British Islands was elevated into land even to that extent you will understand that the streams which drained the South of England and the East of Ireland, and the West of Wales and of England, and the North of France, must have had an outlet into the Atlantic Ocean. We shall suppose, therefore, that there was a river valley draining along the Irish Sea southwards and another draining along the English Channel westward. Now these rivers have originally been indicated by, amongst other geologists;—and principally—your Chairman this evening, Professor Boyd Dawkins. He some time ago described and mapped two important rivers which drained the whole of this region, one through the English Channel and the other through the Irish Channel, and that inference of his—it was partly inference and partly derived from an examination of the Admiralty charts—has been fully corroborated by myself. I have indicated on this map what we may call the Irish Channel river by a blue broken line, all the way, from the centre of the Irish Channel, to the margin of the great declivity. But I think the most remarkable one is that of the English Channel, because it is actually preserved and indicated in the Admiralty chart itself under the name of the "Hurd Deep." This Hurd Deep is about four miles wide, 70 miles in length and 360 feet below the general level of the British platform. But it has silted up, or at any rate it does not show itself in the Admiralty charts, in either direction, for some distance. It does not show itself towards the Atlantic till you get much nearer to the declivity; then it is indicated by a line of ever deepening soundings, going down to the foot of the grand declivity at a depth of 1000 or 1200 fathoms. That river drained all the

streams coming in from the North and from the South, and it seems to me to have risen very near to the Straits of Dover; so that the streams which went out in the opposite direction drained northwards into the North Sea or the German Ocean. Now, going into the Bay of Biscay we find several rivers remarkably indicated by the soundings. The first which is represented is the River Loire. For a distance of about 50 miles the river itself comes down into the sea, from where the indications are very slight, and sometimes absent, owing, as I think you will admit, to the immense amount of silt, sand and gravel, which is spread over the portions of the platform adjoining the land. But when you come to a point about 50 miles from the coast, then the Channel of the Loire becomes very clearly defined. Then you have a series of soundings getting deeper and deeper below the general level of the platform, and opening out on the great declivity. And what is remarkable though it is not a solitary instance;—there is a double outlet. Several of these rivers have double outlets, one slightly deeper than the other, and both opening out in the abysmal region. I am not clear as to the cause of this double outlet; but it is characteristic of the Loire, the Adour, and other rivers. Then, following the margin of the platform, there are several indentations of the platform. One (pointed out on the map) was probably the outlet of the Garonne. But when we get to the point where the Coast of France meets the Coast of Spain, and their range of mountains, the Pyrenees, become continuous with the Cantabrian Highlands, then we have a sufficient instance to enable one to arrive at a general conclusion as to all these streams. Here we have the case of the Adour. This river rises on the northern side of the Pyrenees, and you will observe that in the sea there is an arm which goes to meet it right up from the submerged channel, and a second arm, as shown on

the chart, reaching right to the margin of the land indicated by the soundings. These are called in the Admiralty charts La Fosse du Cap Breton. Now the northern stream has changed its course. The existing stream enters the sea at the apex of the southern fosse. The northern fosse has dried up and given place to it. But the fosse itself existing under the waters of the ocean shows where the river entered at one time. Then five or six miles below the two fosses join, and you can trace the centre of the channel step by step, owing to the great number of soundings in the Admiralty chart there, all the way down till it enters the deep ocean; where there is also the double outlet. I thought this case of the Adour so remarkable and interesting that I have had an enlarged plan made of it, which will be more intelligible to the audience. (By references to this map, Professor Hull was able to show more in detail the features previously indicated). There is one interesting point about the Adour's submerged channel, and confirmatory of its character as an old submerged (or as the Americans would call it, a "drowned") river channel. It is the existence of arms stretching out to meet the existing streams coming down from the Cantabrian mountains. You have in this case of the Adour all the characters of a river—first that of a continuous deeping of the central channel, of a widening of the sides, then of the existence of tributary streams coming down from the neighbouring lands; so that all the characters that belong to a river are found in this, and some of the other channels underneath the Atlantic Ocean. Then coming to the Coasts of Spain and Portugal we continue this investigation and examination of the old channels. I shall only refer to two or three of them, because time will not permit of doing more; but any gentlemen wishing to examine this chart can do so, and he will see how very clear some of these channels are. The platform itself is comparatively narrow here—only 25 to 50 miles in breadth;

but it is penetrated, and the great escarpment or declivity by which it is bounded is penetrated at various points by very deep channels, or, as the Americans would call them, "cañons." Some of these channels were bounded by cliffs several thousands of feet in height. One represented on the chart, I have called the Grand Cañon; and I think I am quite justified in giving it that title. Anyone examining the contours there will see that the 200 fathoms contour is close over the 1,200 or 1,500 fathoms contour, so there must be a tremendous descent in lofty walls of rock, somewhat similar to those of the Colorada region of America. Besides that it may be presumed, that owing to the rapidity with which the channel deepens in some places, there must have been some magnificent cascades, rivalling even Niagara, or those of the Grand Cañon, because it was only by a succession of cascades that the channels could have been deepened to 1,000 or 1,500 feet in a short distance. Another river I will call attention to is the River Tagus—it is the most southerly of those which I have examined and described. The submerged mouth of the Tagus comes very close up to the mouth of the existing river—within five or six miles, in fact, of the point at which the river enters the ocean, and where there is a great accumulation of sand and gravel. At the mouth of the Tagus the old river channel begins to make itself seen by the contours, and from that point to the original ocean margin we have the channel remarkably well defined. At one point, where you see the 200 fathoms contour, there is a descent from this margin down to the very basement of the declivity, at a depth of 1,200 fathoms—a depth of 6,000 feet within a very narrow space. So you must picture to yourself these submerged river channels bounded by walls of several thousand feet, going out in successive steps—I do not say they go down by one sheer descent, but going down by successive steps of

great height and steepness. Now, if you can for a moment picture to yourself the entrance to one of these great river valleys, such as the Tagus, or the Adour—supposing the whole of this region to be elevated to the extent of 8,000 or 9,000 feet above the present level, the ocean washing its base on the western face, the picture afforded by the entrance to one of those great cañons must have been of a very grand and sublime character; but I am sorry to say no human eye ever rested on the magnificent scene.

Before proceeding to exhibit by means of the lantern a series of illustrative diagrams and sections, the lecturer exhibited and explained several sections, including a section across the "Irish Channel River," and a section off the West Coast of Ireland, where the platform runs out for about 200 miles, and then passes by a declivity to the floor of the abysmal ocean. There were also sections across the river channels at various points, showing how characteristic they are of true rivers.

After exhibiting the lantern slides, Professor HULL proceeded: Now, you will naturally inquire, at what geological period do I suppose these features were formed? I need not say, in the first place, that it is utterly inconceivable channels such as I have described could have been formed by any natural processes under the ocean itself. Once a river enters the ocean its current is very soon destroyed by the water which it meets, and it is incapable of channelling out great valleys such as those I have described, so we must suppose that when these river channels were in course of formation the whole of this region was elevated into land to the extent of several thousand feet above the present level. Now, as regards the geological period at which this took place, it is quite clear from one consideration that it is really comparatively of yesterday—most modern—most

recent—not dating back certainly further that the Pleiocene, because these submerged river channels are continuous with those of the existing rivers, and you know that all the features of the South and East of England have been brought into existence since the Eocene, during the Miocene and during the Pleiocene epochs; so that the channels which have physical continuity with them must be referable to a similarly recent geological period. But I go beyond that, and I express my belief that these river valleys were formed mainly at the commencement of the glacial period. Now, consider for one moment what would have been the climatic effects of elevating the Western part of Europe—and when you elevate this Western part of Europe several thousand feet you must also elevate the region extending Eastward, and the region over the Atlantic. And when as I said that the American geologists have established similar features on the coast of America extending to the Western shores of the Atlantic, then you must come to the conclusion that the whole of the Northern Atlantic Ocean has been elevated into land several thousand feet above its present level. What would be the effect on the climate of this region under such conditions? Surely it would be to establish glacial conditions. You would bring vast tracts of land into the atmosphere where the cold would be almost arctic—certainly in the Northern portion of the British Islands, and to a certain extent also Southwards into Europe and the Mediterranean regions. You would be producing effects which would result in the production of a glacial period. And here you have, I venture to say, a very clear, simple, and intelligible cause for that wonderful, mysterious period which preceded the introduction of the human race on the globe, at any rate in this part of the world, known as the glacial, or post-pleiocene period, during which our mountains were covered with snow and ice, sending down glaciers to

the plains, and scattering boulders over those plains, of which you have some magnificent specimens in the precints of this College. Those great boulders were carried by ice, either in the form of floating or land ice. At any rate, I venture to say that we have in this general elevation of the North Atlantic region, on both sides, a simple and easily intelligible cause of what we call "the glacial epoch."

The CHAIRMAN: I am sure, ladies and gentlemen, it is not at all my duty to do anything except express, on my own part, the great pleasure with which I have listened to this admirable address by Professor Hull. Mr. Stirrup will move a resolution.

Mr. STIRRUP: It gives me indeed very great pleasure to be called upon to propose a vote of thanks to Professor Hull for his excellent address. Professor Hull is not a stranger amongst us. To some here he has been known for many years. When he was stationed in Manchester, on the geological survey, he was an honorary member of a society, with which I was connected, but which is now extinct—the Scientific Students' Association—and I remember that he gave us generous help with lectures then, and he has this evening made good a voluntary offer, made some few months ago, to visit us and give us a lecture in Manchester again. The subject which he has brought before us to-night is one of very deep interest, and one which may present novel features to many of you. It may be new to some to learn that this earth is not the steady body they may have imagined, but that it has had fits of elevation and fits of depression, such as are depicted by the soundings marked on these charts on the wall. But there is one thing, I think, which the Professor has not explained, and I do not know whether any one is able to explain it, that is,

the *cause* of these uprisings and depressions of the land, and these interchanges of land and sea. We do not seem to have grasped, as yet, the *primum mobile*, or the cause of these changes; but they occur, and have occurred, ever since the world, as we know it, came into being. There are many other problems connected with the subject, there is the one which Professor Hull concluded with—he considers that he has discovered the true cause of the glacial epoch. But Sir Robert Ball, the eminent astronomer, has found another "true cause," which, however, does not seem to agree with recognised geological data, but which, as the witty Professor says, is so much the worse for geology. I think there is much more evidence in favour of the theory which Professor Hull has advanced this evening. I have very great pleasure in moving that the best thanks of this meeting be given to Professor Hull for his excellent address.

Mr. Joseph Dickinson said: I have very great pleasure in seconding the motion of Mr. Stirrup—that our best thanks be given to Professor Hull for the very interesting and able address he has given us. I think it is nearer forty years than thirty (as stated by Mr. Stirrup) since I first knew Mr. Hull come amongst us; he was then an experienced geologist, and he had commenced laying down the geology of the coalfields of Lancashire, which in the Geological Maps has proved of so much service to the mining community, and others. You have heard his address to-night. He is now in his full maturity. He was an able geologist then; he has had forty years' experience. No one can complain of any loss of originality on his part. We may not all be educated up to what he has laid before us this evening, but he has given us food for reflection in laying down these river channels beneath the

ocean, and the contour lines off the coast of Europe and extending to 500 or more miles to the West. I have much pleasure in seconding the vote of thanks to my old friend, Professor Hull.

The resolution was passed with acclamation.

Professor HULL, in responding, said: It is a great pleasure to me to receive such a warm vote of thanks. The subject is one on which I am a bit of an enthusiast, and every enthusiast likes to propagate his opinions, whether they are good, bad, or indifferent. But I venture to think that my opinions are good, therefore I am the more eager to propagate them, particularly among my old friends and colleagues of Manchester. I never look back to the time when I was stationed here, on the Geological Survey, without feelings of pleasure and interest. I knew nearly all your great scientific men in Manchester; they were personal friends of mine—Angus Smith, Dr. Joule, Mr. Baxendell, and others, who were the shining lights of the Literary and Philosophical Society of Manchester. I will only say that I am amply rewarded for coming here by the audience, the intelligent audience, which I have had the pleasure of addressing, by the hearing they have given me, and I may say by the extent to which they have fallen in with my views. That, I assume—though I do not know—is a fact. I hope it is.

Mr. STIRRUP then took the chair, and called upon Mr. Bailey to move a resolution.

Mr. CHARLES BAILEY rose and said: Perhaps it is because I belonged to that group of old students to whom the lecturer referred that I have been asked to say a few words to-night, in submitting a resolution. But another word of thanks to Professor Hull may be permitted for the extremely

able lecture he has given us. His subject has a close connection with commercial life, because that life depends largely upon the good bedding of our telegraph cables. From the graphic description Professor Hull has given of that wonderful escarpment which is situated off the western coast of our islands, as well as of France and Spain, it is clear that a great deal of mischief may have been done in the past by laying the cables in wrong channels and letting them hang over submarine chasms, or rest upon the sharp ridges of the escarpment. Professor Hull having shown us the old river channels, and where the cables could best be laid, illustrates the service which the man of science renders to the man of commerce. My resolution is that we thank Professor Boyd Dawkins for his ability in the chair to-night. He is an ideal chairman; he did not, as so many would have done, give us in advance the substance of what the lecturer had to say: for that reticence we thank him,—we like to get the facts direct from the fountain head. Well, that endears Professor Dawkins to us—besides other things. Another part of the resolution is not less important than that already indicated, namely, that we thank Principal Hopkinson for his kindness in allowing us to meet in this room to-night; he has done himself and the College an honour in permitting so able a lecturer as we have listened to to-night to address an audience here. I therefore propose that our hearty thanks be given to Professor Boyd Dawkins and Principal Hopkinson.

Mr. C. E. De Rance said: I have very great pleasure in seconding the motion of Mr. Bailey for many reasons—first of all, because the lecturer to-night was the officer of the Geological Survey who was commissioned by our old chief, Sir Andrew Ramsay, for the survey of this very county. I have also great pleasure in seconding it because I happen

to be an Honorary Member of this Manchester Geological Society. With this membership I have always been pleased, because it has done me many a service, one of which is that it has enabled me to hear this exceedingly able lecture given by my old friend and ex-colleague, Dr. Hull. I cordially agree with what Mr. Bailey said—that we all owe our thanks to the Principal of Owens College for allowing the use of this room, and I also agree with him that Professor Dawkins makes an ideal Chairman.

The resolution was carried unanimously.

Principal HOPKINSON briefly responded, remarking that he quite agreed with Mr. Bailey that it was a benefit to the College to hear lectures within its walls such as that which had been given by Professor Hull, and to welcome back one who was so well known to the scientific men of Manchester almost a generation ago. It was also a benefit to the College, as well as to themselves personally, to welcome those in the town of Manchester who were interested in scientific work. The lecture they had heard had been an instructive one, and on the controverted point upon which the Professor had touched the evidence he had brought forward seemed—to a lawyer's mind at any rate—absolutely convincing.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XII. VOL. XXVI. SESSION 1899-1900.

The ORDINARY MEETING of the Members was held on Tuesday, November 14th, 1899, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. J. S. BURROWS, in the absence of the President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected members of the Society :—

Mr. RICHARD LEAH, Smedley Road, Cheetham, Manchester.

Mr. SAMUEL B. BENNETT, 60, Gloucester Road, Urmston.

PIT PROPS AND THEIR SETTING.

By Mr. Joseph Dickinson, F.G.S.

CONTENTS.

I. Outline.
II. Authorities on the physical properties of wood.
III. Ditto on propping mines.
IV. Deductions (*a*) properties of wood.
Ditto (*b*) setting props.
Ditto (*c*) comparative tables of the strength of pit woods.

I.—OUTLINE.

The date when mining began is unknown. The first working of minerals would be upon surface deposits and outcrops and become gradually extended underground. Propping the ground would soon follow. The use of metals is known to be very old. Genesis records good gold being found on land at the earliest date to which it traces the lineage of the Jews 5903 years ago, and an instructor of artificers in brass and iron 5774 years ago. The Book of Job also at the still very remote period of about 3419 years ago, describes the finding of placer or alluvial gold and the mining of ores, mentioning mining dangers including those from stones; but unfortunately (especially in the revised version) the translators seem to have found difficulty in interpreting the technical mining terms of the ancient language.

Long after this comes Agricola, 343 years ago; and afterwards a long list of authorities on the strength and best methods of setting props.

Every ordinary kind of timber has been tested. Straight grown light woods have been preferred for propping, yet in

their absence logs have been split or sawn into suitable sizes and used; and for building supports, called chocks and cogs, either hardwood sawn into blocks, or props or the remains of broken props have been used.

The home supply of suitable props being inadequate, large quantities are imported, notably from the Baltic ports.

With the present experience it is considered that generally ordinary danger from falls of ground may be guarded against, and that almost any loose or broken ground may be securely timbered through. Yet, notwithstanding all that has been done, some diversity of opinion remains as to the strength of common prop wood and as to one point in the system of setting props.

In hopes of reconciling these remaining discrepancies this monograph was begun some time ago, but was laid aside when the account of Professor H. Louis's experiments on actual pit props introduced further differences. The subject at present being however so puzzling to the student, it is now taken up again, trusting that discussion by this Society will help in bringing about definite conclusions.

For this purpose it seems best in the first place to quote from a few of the authorities on the strength of timber and on the setting of props, and to follow with a few deductions and comparisons. In so doing the casing of shafts and arching main entrances will not be touched upon, but only timbering roadways and working faces.

II.—AUTHORITIES ON THE PHYSICAL PROPERTIES OF WOOD.

Thomas Young, M.D., 1807.

According to this comprehensive reprint in two demy quarto volumes of a course of lectures delivered a century ago on Natural Philosophy and the Mechanical arts before the Royal Institution of Great Britain, it is evident that

long before that time the passive strength of materials of all kinds used in the mechanical arts had been carefully investigated. The author of the work although he knew Newton's rule that, "in philosophising no more cases are to be admitted as existing in nature than are true and sufficient for explaining the phenomena to be considered," yet in relation to timber alone he mentions by name 22 different authorities between the years 1665 and 1797 from whom he quotes.

The principal effects of any force acting on a solid body had then been reduced to seven denominations:—compression, detrusion, flexure, alteration, torsion, extension, fracture.

Experiments had been made with machines capable of measuring the tensile and compressing strains, a drawing of one of which is given among the numerous plates, the forces being indicated by a graduated steelyard.

The size and construction of this machine were such as to admit substances of moderate length for tensile tests, and of much larger pieces than one inch cubes for compression. Possibly small pieces were used, and the samples may or may not have been selected. The text sets forth that the testing of columns was restricted by the limited magnitude of the machines and edifices.

There was not any easy mode of detecting flaws in a bar of iron. Stone when beginning to give way threw off small splinters, and was said to be capable of supporting by much the greater weight when placed in the same position with respect to the horizon as that in which it was found in the quarry.

As TO WOOD, the principal conclusions arrived at were:—

The strength of the various woods in bearing pressure was often taken at—Alder, asp, birch, white fir, willow 6000 lbs. per square inch; larch 6200; beech, cherry,

hazel, basel 6666; red fir, holly, elder, plane, apple 7000; thorn 7500; elm, ash 8500; box, yew, plumtree, oak 11000. These results, however, differed materially from others.

The strongest wood of each tree is not in the middle, but between the circumference and the centre, and generally in Europe the south east side is thicker than the north west side.

Wood becomes stronger when dry.

With partial compression and extension insufficient to alter the structure, strength remains unaffected.

When the forces are such as to cause a creaking noise or in any way produce alteration of structure, the strength becomes much weakened; although the wood may still retain strength enough to be of service for some purposes.

The crushing strength is generally much less than the tensile strength; and the transverse strength is from 7 to 20 times weaker than in the direction of the fibres.

Fir suspends much less weight than oak, but oak even when externally straight supports less than fir.

The strength in resisting compression is liable to great variation.

With columns or rods exposed to longitudinal forces, flexure or bending is the most usual manner in which fracture is produced. Soft and green wood fails first on the concave side; but hard and seasoned wood fails first on the convex side. This was attributed either to the want of external straightness, or to the internal structure of the fibres causing the superficial parts on the convex side of hard woods to become most extended and give way first, but the reverse with soft and green woods. It was undoubted that some of the irregularities were occasioned by the difficulties of applying the forces precisely at the extremity of the axis.

The experiments also showed, at least with comparatively small forces, that with uniformly elastic substances the measure of compression produced by certain weights increased very nearly in ratio with the increases of weight. And that the same weights acting in a contrary direction elongated the substance in the same ratios, the compression and extension by the same weights being equal. For ordinary substances this was taken to extend to one half. But very elastic substances, such as gum, were exceptional. With these elastic substances the force capable of compressing them to half the length usually elongates them to many times their length. According to this analogy, the elasticity of any ordinary substance was expressed by the height and corresponding weight of a column of the same substance, denominated the modulus of its elasticity. This measure was then considered to be sufficiently confirmed by experiments as a good approximate measure. (See tables IVc.)

Adcock, 1843.

In 1843, Adcock in his 'Engineers Pocket Book', quotes from authors and gives other information as to specific gravities, weights, and forces; detailing tensile strength as that "necessary to tear woods &c. asunder when pulled in the direction of their length;" also certain rules for finding lateral and transverse strengths to bear a given weight in the middle; and as to crushing strengths he recites the proportional rates given by Dr. Young.

Templeton, 1847.

In 1847, Templeton, in his 'Engineers and Contractors Pocket book remodelled and improved,' gives from Tredgold &c., specific gravities, weights, transverse strength or resistence to lateral pressure when loaded in the middle, cohesive force, comparative stiffness strength and resiliance,

weight of the modulus of elasticity but without the corresponding height of a column of the substance, &c.

In a note he explains certain of the terms used. Resiliance or toughness is strength and flexibility combined, hence any substance which bears the greatest load and bends the most at the time of fracture is the toughest. A hard substance is that which yields least to any stroke or impressive force, the degree of yielding in uniform substances being always proportional to the weight of their modulus of elasticity—the modulus of elasticity being the measure by which the comparative stiffness of substances may be ascertained. The modulus for oak is 1,714,500 lbs., and for cast iron 18,400,000 lbs., or 10·7 times that of oak; therefore a piece of cast iron is 10·7 times as stiff as a piece of oak of equal dimensions and bearing.

See details in the tables (IVc.)

MOLESWORTH, 1899.

This useful little Pocket book of 'Engineering formulæ' has now in 1899 attained its 24th edition. Since the first appearance in 1862 various emendations have been made and new information added. In relation to timber are given:—the weight which the respective kinds will bear without permanent alteration, crushing weights, tensile strength, transverse strength, specific gravity, weight of a cubic foot, weight of a cubic inch, and the weight of the modulus of elasticity. To some of the formulæ extended and amended explanation is now given, for which many tyros will be thankful.

In Molesworth's early editions the transverse breaking weight was represented as the force necessary to break a bar one inch square projecting horizontally one inch beyond the point of support, the weight being applied at the outer end. That representation is now withdrawn. The height of the column of the modulus of elasticity given in the

early editions is also withdrawn, and now only the weight corresponding with the height is given, and that as usual in round numbers. His definition of the extreme limit of the modulus differs from that given by Dr. Young. Molesworth instead of terminating it half way carries it on to zero. He also puts it as the force that would lengthen a bar of certain section to double its length or compress it until its length became zero. He also gives a rule for calculating the alteration in length due to any force less than the modulus, and a rule to find the compression or extension of any body within its limits of elasticity.

Some of his conclusions for judging, storing, and treating timber are :—The slower the growth of the tree, as shown by narrower annular rings, the better. In resinous timber, that with the least resin in the pores is strongest and most durable. In non-resinous timber, that with least sap or gum is best. In stacking, the but-end should be downwards, and the butt exposed to the action of the air. It should be seasoned before it is used. If a desiccating chamber be used, for every 3 cubic feet of air in the chamber, 1 cubic foot of air per minute should be supplied—at a temperature of 100° Fahr. for hard wood in logs, and 120° for pine. Proper creosoting about doubles the life of wood sleepers. Impregnation with metallic salts has not in all cases been satisfactory. See tables (IVc.)

Professor Henry Louis, M.A., 1897-99.

The details of these recent tests of the weight which actual pit props will bear are given in the Transactions of the Institution of Mining Engineers Volumes 15 and 17, a copy of which is in the library of the Manchester Geological Society and will well repay careful perusal. The first series of experiments consists of 191 props of Baltic red and white softwood, larch, and Scotch fir; and the latter series of oak.

The following is a brief summary of some of the proceedings and results.

Before testing, the end of each prop was carefully squared. The length of the props varied from 12 to 66 inches, and the minimum diameter of the smaller or top-ends from 2·35 to 6·10 inches. The breakages of the Baltic, larch, and Scotch were 63 per cent. by buckling or flexure, 25% by crushing, and 12% by shearing or breaking off slantways. All the oak props, 7 in number, broke by flexure.

The average breaking weights in pounds per square inch of area of certain of the props, as shown in the accompanying tables were:—Baltic red and whitewood props 3835 lbs., ditto creosoted 3434 lbs., ditto salted 3555 lbs.; larch 3587 lbs., ditto salted 3777 lbs.; Scotch 2521 lbs., ditto creosoted 2614 lbs. Oak 2186 lbs.

The tables show that the strength of each kind of wood varied very considerably between the maximum and minimum. So likewise did the ratios of strength to age of growth shown by the annular rings. But variations of strength according to the diameter and length of props were not discernible from the ordinary variations. The strength of creosoted and salted props also varied.

Berginspector C. Dütting, 1898.

The experiments made by Herr Dütting at König colliery, Neunkirchan, as described in a paper read by him before the Munich Bergmannstag, comprised numerous tests made by machine with actual pit props. The woods tested were chiefly beech, fir, pine, and oak. The length of the props varied from 39 to 99 inches, with an average diameter of a little more than 5 inches, the average area being 20 square inches. The breakage weight of these woods when dried averaged, in lbs. per square inch of area—beech 3627, fir 3385, pine 2958, oak (the same as pine) 2958.

Nearly all the props broke by flexure. Fir gave most warning by crackling, then pine; beech and oak gave least.

For durability in return airways, pine showed best, then fir; beech being bad, and oak worse.

Other woods were also tested; hornbeam did not prove strong; birch proved stronger than beech, and acacia similar to fir.

Mr. George L. Kerr, 1898.

In a paper read before the Mining Institute of Scotland, on 'timbering and supporting underground workings,' (Trans. Inst. M.E., Vol. 16), Mr. Kerr traverses Professor Louis's conclusions that within ordinary limits the strength of pit props is practically independant of their length, and he quotes Mr. Thomas Box's mean crushing strains of wood—Ash 9023 lbs. per square inch, beech 8548, elm 9140, fir, spruce 6657, oak 8271, pine, red 6457, larch 4385.

III.—AUTHORITIES ON PROPPING MINES.

Georgius Agricola, 1556.

This is the oldest book describing the timbering &c. of mines which the writer of this paper knows. The author of it was, it seems, George Landmann, a medical gentleman, who assumed the name of Agricola. It is a foolscap folio volume, a copy of which the writer possesses and another copy is in the library of the Manchester Geological Society. The text is illustrated by numerous drawings. Methods of propping mines are shown with single props and double timbers or couplings. The legs of some of the couplings go up to the roof, and the coupling is inserted between them near the top; but others have the coupling placed upon and projecting over the top of the legs. Behind the couplings, the sides of some main roadways are cased with planking. The single props are mostly in the natural state

of the wood, but most of the double timbers are squared. Some of such of the legs of the double timbers as are in the natural state have naturally grown forks at the top end, and in this fork the coupling is placed. Neither cogs nor chocks are shown in the drawings of the workings, but some buildings aboveground have the side walls formed of natural timber crossed in the same form as cogs.

REPORT TO THE MINING INSTITUTE OF SCOTLAND, 1881.

This report by Messrs. H. Mungall, J. Drinnan and R. T. Moore, B.Sc., 'On supporting coal mines,' describes almost every method of propping as practised in England, Scotland, and Wales. It describes and the diagrams show:—Single props, double timbers gears or couplings, sprags or stays, chocks and cogs, set in various ways. The single props, are with caps or lids between the top end and the roof. The double timbers, include the complete set having a prop at each side from the floor to the coupling or crown piece at the roof; others with one or both legs resting on ledges part way down: the crown pieces of some are single; others are in two pieces slanting upwards and meeting at the top; some are in three pieces, two of them slanting upwards, and a short horizontal coupling at the top: the junction between some of the legs and the couplings are notched, the tightening being with pieces of wood hammered in above and at the sides; other legs are cut concavous at the top, to receive the convex coupling, against which the legs are hammered up and sometimes nailed, and occasionally a diagonal stay is inserted at each corner to strengthen the coupling. Iron props had scarcely come into use at the time of the report, but arched iron couplings are shown. The sprags or stays, have mostly caps, some being set in double rows and others single; those called cockermegs are composed of a diagonal sprag sloping forwards from the floor to a cap against the coal face with

another diagonal sprag sloping backwards from the same cap to the roof. The chocks, are of the usual square timber cut in lengths suitable for the height of the working; and the cogs are of natural round timber, sometimes broken props.

The diagrams in this report show most of the props set vertically in horizontal mines, and at rectangles to the bedding in inclined mines. But some are at different angles.

The utility of the lever and chain for safety in drawing props, or at least dangerous props, which require renewing or when the temporary purpose for which they were set has been served, is also mentioned.

This valuable report is in the library of the Manchester Geological Society, and is well worth perusal.

Messrs. John L. Hedley and Wm. Leek, 1898.

This instructive paper, on 'Timbering in the iron ore mines of Cumberland and Furness,' describes some variations of procedure. Trans. M.E. Vol. 16.

Mr. George L. Kerr, 1898.

This paper, previously alluded to on the strength of timber, quotes Mr. A. R. Sawyer's book, defining the angles at which props should be set, varying according to the inclination of the mine.

IV.—DEDUCTIONS.

(a) Properties of pit woods.

On comparing the results of the tests of wood by different experimenters a student may be puzzled by the variety of names given by different authors to the same force, and to the same kind of wood, and sometimes even to the same term. For instance, transverse strength is variously described as—the weight which a beam loaded in the centre

will bear; as that necessary to break a bar projecting one inch beyond the fulcrum; as that necessary to break a bar projecting 12 inches beyond the fulcrum; and also as the crushing weight across the fibres. These and such like, until uniformity be attained, have to be mastered according to the best of each person's ability.

The general results of the tests show without doubt that the strength of the same kinds and also of different kinds of wood, as well as the weight which woods will bear without permanent alteration, vary considerably.

The crushing weight of white fir per square inch of area was put by Dr. Young a century ago at 6000 lbs., and red fir at 7000 lbs. Molesworth now puts yellow pine at 5300 lbs., and red pine at 5400 lbs. Professor H. Louis's recent tests of 191 actual pit props make the average weight much less. Taking 57 of his tests of Baltic props as a sample, each either partly or fully seasoned, in lengths from 12 to 67 inches, and diameters of the point ends 3·33 to 5·12 inches, give only 3835 lbs. per square inch, the range between maximum and minimum being from 5687 lbs. to 2688 lbs. Berginspector Dütting's experiments also with props, seasoned, in lengths from 39 to 99 inches, and average diameter a little less than 5 inches, averaged less—fir 3385 lbs., and pine 2958 lbs. The crushing weights of other kinds of wood being similar. See tables (IVc.)

The weight which woods will bear without permanent alteration is put by some authorities at from 50 to 70 per cent. of the crushing weight. Others vary the percentage according to the hardness of the wood—thus; putting figure 1 as the weight all woods will bear without permanent alteration the crushing weight is; for soft wood from 1·35 to 1·50, and for hard wood from 2·43 to 2·81. The deterioration is such that a prop which has been

subjected to pressure beyond its elasticity will not again bear the weight it was capable of supporting before its original latent strength became impaired. Nor, seeing the difference between the maximum and minimum strengths, should even a new prop be trusted to bear the average breaking weight shown by the tables.

The modulus of elasticity was a century ago considered sufficiently confirmed by experiments as a good approximate measure of the elastic force of ordinary substances. Now, some of the principles on which former tables were based have become changed. Dr. Young (excluding highly elastic substances such as gum) put the limit of compression and extension of ordinary substances at one half. Molesworth in his 24th edition 1899 puts it at zero—that is supposing it possible to stretch or compress the ordinary substance to this extent, and that the relation between compression and extension held good. The tables usually give the modulus per square inch of area, but the modulus is the same whatever the area may be. Old tables give the height of the column of the substance in feet, and the weight of it in pounds. Most of the new tables give only the weight, but the bulk or height of the column may be readily calculated when the specific gravity of the substance is known. In the tables both of weight and height, fractional parts of a thousand are often omitted as being variable where the tabulated specific gravities vary, and unimportant among numbers extending to millions, and the measure only approximate.

The old authorities attributed the differing results of strength found in the same kinds of wood chiefly to external crookedness and internal twisted fibres. These they considered caused seasoned wood to give way first by flexure on the convex side, and unseasoned wood on the concave side. Also in some degree to the wood at the S.E. side of the pith

of trees in Europe being generally thicker than the opposite side. They also thought it possible that in all instances the force in testing might not have been applied precisely at the extremity of the axis.

Recent authorities attribute the differing results of the old and new tests to the wood used in the old experiments being selected and in small pieces, whilst the recent experiments have been upon full-sized and unselected props.

Whether the wood used in the old tests was actually selected or otherwise does not appear; but that the pieces were small is somewhat confirmed by Dr. Young's statement that some of the results may have been affected by the limited magnitude of the machines and edifices. He does not specify the size, but the drawing of the machine in his book shows that the machine although not adopted for testing long props, was yet of sufficient size for making tensile and crushing tests of very much larger pieces than one inch cubes, as recently supposed.

The fact that in both the old and the new tests a large majority of the breakages were preceded by flexure tends to confirm the views of the old authorities as to the cause of the variations of strength. Possibly the cause of variation is explainable in some instances by the maximum stress of some sets of tests being compared with the average stress of other tests.

According to the recent tests the strength of props is shown not to be materially affected by the diameter, length, age of growth after a certain maturity, nor by either creosoting or salting, provided the props be properly seasoned before use. In some aspects, however, some of these conclusions seem to require consideration.

As to the diameter:—In Professor Louis's tests of 191 props, with diameters varying from 2·35 to 6·10 inches and an average area of 13·78 inches, some props of small diameter

stood more pressure per square inch than those of larger diameter, but others stood less pressure. Certain tests made of adjoining parts of the same wood showed that the upper or smaller ends averaged 3 lbs. per square inch stronger than the but-ends, and that the maximum crushing weight was also in their favour. The minimum crushing weight was, however, in favour of the larger or but-ends.

As to the length of the props—although the experiments with props varying in length from 12 to 67 inches, and diameters varying accordingly, scarcely showed that length affected the strength, it is obvious that the bigger the bulk the more room there is for change, and that parallel columns adding to the load must operate against strength. It is also apparent from the modulus of elasticity that increase of length of a column of any ordinary substance of uniform section proportionately lessens the extraneous weight it will bear. The anomaly as to length shown by the experiments may be partly due to the taper of the props, the strength per square inch being calculated from the area of the point end. The size of the but-ends is not given, but in the instances where props were sawn in halves it may be seen that the diameter from point to butt increased in the Baltic props from 1/10th to 1/7th of an inch per foot, and in the larch props about 1/8th inch per foot. (See also Molesworth's formula for columns, 24th edition, 1899.)

As to the age of growth, shown by the annular rings, the experiments show that after certain maturity strength is subject to variation. Some of the Baltic whitewood, commencing the count at 24 years, attained the maximum strength at 52 years, which it nearly maintained to 77 years. Mixed Baltic props, beginning the count at 45 years, attained the maximum strength at 66 years. Some larch, beginning the count at 8 years, fluctuated to 13 years and attained the maximum strength at 19 years, and

diminished afterwards to 30 years. Some other larch of inferior quality, beginning the count at 23 years, attained the maximum strength at 29 years. Scotch fir—green and full of sap, beginning the count at 16 years, increased in strength to 20 years, then declined to 25 years, but rose again and attained the maximum at 78 years. Another kind of Scotch fir with some seasoning, beginning the count at 15 years, attained the maximum at 23 years, and then fluctuated to 36 years; whilst some with 3 months more seasoning, beginning the count with the maximum at 10 years, declined in strength to 25 years growth.

As to CREOSOTING AND SALTING, the tests showed:—Baltic props fully creosoted but only partly seasoned broke at an average of 2890 lbs. per square inch. Others lightly creosoted but well seasoned before using averaged 4126 lbs. Those partly seasoned before the testing being 945 lbs. against creosoting, and the fully seasoned 291 lbs. in favour of the light creosoting. Some of the salted props varied in strength—the partly seasoned breaking at 560 lbs. per square inch less, and the well seasoned at exactly the same weight as those not salted. Treatment with metallic salts, it appears, has not in all instances proved satisfactory.

In SELECTING PROPS, the principal points to be observed are:—Straightness; slowness of growth as indicated by narrow annular rings; freedom from knots, indents, resin, gum, and sap. They should also be well seasoned before use. With these precautions and proper mine ventilation, fungus growth may generally be obviated and durability ensured.

(*b*) Setting props.

In ancient coal mining the drivings seem to have generally been made only so wide as the roof would stand without propping, pillars of coal being left for support instead of using timber. In metalliferous mines also the

use of timber seems to have been avoided so far as practicable. From the iron ore mines of the Forest of Dean in Gloucestershire many well preserved solid oak spades have been shown as 'finds' in the ancient workings, but the writer although knowing the mines well has seldom if ever found remains of ancient prop wood. Props were, however, undoubtedly used in Agricola's time between three and four centuries ago, but not so abundantly as now.

At the present time with an almost invariably adequate supply of props strong enough for the purpose and to some degree enforced setting, falls of ground constitute a most serious cause of accident. Greater in importance therefore than the relative strengths comes the consideration of the proper methods of setting. The differing practice which to an observable extent obtains in this respect is the point to which the writer now invites attention. Namely, whether all bearing props should be set in the direct axis of main pressure, or whether sufficient others should be purposely added sloping differently to guard against side thrusts which come occasionally from breaks, faultings, and anomalous subsidence.

It seems generally agreed that the main weight in mines comes nearly at right angles to the bedding, and that the props should be mainly set in that direction. If the mine is horizontal the weight generally comes vertically, but if the mine is inclined the weight comes at a right angle to the inclination. Ordinarily the props are set in these directions. They are set by the eye, which with other circumstances occasions some variety in the setting. This variation generally, but not always, prevents side thrusts toppling them over.

Some authorities hold it as a principle that all props should be set at a rectangle against the main pressure.

Others, in order to guard against possible side thrusts and a tendency of the ordinary weight to ride to the dip in inclined mines, purposely cause a sufficient number of props to be set slightly deviating from the common axis.

The diagrams in Messrs. Mungall, Drinnan and Moore's report show most props set at right angles to the bedding, but some deviating from the majority. Mention is not made in the text whether this difference came specially under their notice.

Mr. Sawyer's endeavour to fix a maximum and minimum slope for the props varying with the rate of dip seems a step in the right direction. If his proposal be rightly understood it is to make this maximum slope of the props 1/6th of that of the dip, and the minimum slope 1/3rd of the 1/6th, which might admit of more scope for variation.

From the want of sufficient variety of slopes, the writer has seen whole uniform settings topple over without breakage of props, which could not have happened if a little diversity of slope had been given to a sufficient number of the props. To this point special attention is requested.

Props are usually set with the but-end downwards, but not always. Having the but-end upwards adds a trifle to the weight on the lower end, but the larger size at the top should lessen the liability of its being split by a coupling resting on it, and also gives more surface for abrasion in hammering up against a rough roof. Both ways may therefore have advantages according to the circumstances. The but-end downwards with air circulating is the way Molesworth recommends for stocking. But it differs from the old notion that wooden gateposts inserted in the ground last longer with the direction of growth reversed. Stone is held to last best when laid in the same horizon as it was bedded in the quarry.

The utility or otherwise of sloping a little off the edge of the ends of props or of surrounding the ends with an iron

ring to prevent abrasion, to which some members of this society have attached usefulness, does not seem to have been tested by the machine process. Either device should prevent abrasion of the ends of props; and the sloping off, if skilful in modifying irregularities of axis to the direct line of pressure, should add strength to props generally.

Props which have become dilapidated but where support is still required must be changed. But consideration is required whether other props which without failure have served the purpose for which they were set should be drawn or left. The taking out requires skill and care to avoid danger. A few managers prohibit it altogether. Some require the drawing to be done only by experienced miners, or by those persons who set the props or who know of any special causes for which some of the props were set. Others allow its being done by the miners generally. Ordinarily it is considered best to draw all props which appear safely available. The so doing prevents waste of property, admits of regulating weight which sometimes usefully assists in the working, and allows the roof to subside or fall regularly in the worked out part behind.

In this drawing of props, a hammer and pick with occasionally a long prop as a battering ram are used. At times a temporary prop may be set for protection during the operation; and when taking out critical props, various appliances such as the lever and chain are used, the lever being sometimes substituted by attaching the chain to a windlass or a moving tram. It being found that appliances of this kind are oftener provided than used, Her Majesty's Secretary of State supported by the Inspectors of Mines is endeavouring to make the use of some such adjunct obligatory. To this endeavour, so far as it does not injuriously interfere with the judgment of a skilled operator, all must wish success.

(c) Comparative tables of the strength of pit woods.

As preface to the few comparative tables of the strength of some common pitwoods, acknowledgment is due to the scientific and practical authorities and to the societies and institutions which have spread so much information to help in fitting mining engineers and managers for their responsible duties. The writer of this paper closed his first official report as Her Majesty's inspector of mines, in June 1851, with the words of hopefulness expressed at the opening of the Royal school of mines, that it would remove the cause for regret "to find many a powerful mind struggling with a want of knowledge of what others have accomplished or are now doing—great as the achievements of uninstructed men have sometimes been they would have been still greater had correct instruction been afforded them." Before that, in 1818, the Royal Institution of Cornwall was founded. In 1838, this Manchester Geological Society with its two objects of geology and mining was established. In 1839 continuing in 1840, Sir Charles Lemon originated a mining school at Truro. In 1850, the Inspection of mines began. In 1852, the now great Institution of mining engineers at Newcastle-on-Tyne was founded. Numerous other important mining institutions and schools have followed, including technical schools embracing other subjects. Severally and jointly these have realised the most hopeful anticipations. More remains to be done. Let us trust that increasing wants will be met by increased usefulness.

The tables here appended summarise some of the varying results of the tests of the strength of woods commonly used for propping mines, including the tests of actual pit props; and the modulus of their elasticity.

Comparative Tables of the Strength of Common Pit Woods.

The strength is given per square inch; which mutiplied by the total area gives the total strength.

Authority.	Kind of Wood.	Specific Gravity.	Strength in the direction of fibre. Per square inch.		Transverse Strength. Per square inch.
			Tensile or Cohesive.	Crushing or Breaking.	
			Lbs.	Lbs.	Lbs.
Dr. Thos. Young, 1807	Ash ..	·84	12,000	8,000	Six to twenty times weaker than in the direction of the fibres.
,, ,, ..	Beech ..	·85	12,000 to	6,500 to	
	,, ..	..	17,000	8,000	
,, ,, ..	Elm ..	·80	13,000	8,000	
,, ,, ..	Fir, white ..	·56	8,000	6,000	
,, ,, ..	,, red ..	..	..	7,000	
,, ,, ..	Oak ..	·99	12,000 to	4,000 to	
	,, ..	..	17,000	11,000	
Adcock, 1843	Ash ..	·840	16,700	..	
,, ,, ..	,, red ..	·812	17,892	..	
,, ,, ..	Beech ..	·720	17,709 to	..	
	,, ..	..	22,200	..	
,, ,, ..	Elm ..	..	13,489	.	
,, ,, ..	Fir, pine .	·590	12,400	..	
,, ,, ..	,, Norway	·660	14,300	..	
,, ,, ..	Oak ..	·760	14,000	..	
Templeton, 1847 ..	Ash ..	·845	15,780	..	
,, ,, ..	Beech ..	·852	12,000	..	
,, ,, ..	Elm ..	·673	11,500	..	
,, ,, ..	Fir, red pine	·657	9,540	..	
,, ,, ..	,, white ,,	·551	12,346	..	
,, ,, ..	Larch ..	·530	9,500	..	
,, ,, ..	Oak ..	·743	11,592	..	
Molesworth, 1899 ..	Ash ..	·690	12,000	8,600	2,000
,, ,, ..	,, ..	·760	17,000	9,300	3,000
,, ,, ..	Beech ..	·690	11,000	7,700	1,500
,, ,, .	,, ..	·696	22,000	9,300	2,000
,, ,, ..	Elm ..	·553	13,200	10,300	782
,, ,, ..	,, .	·579	14,000	..	1,100
,, ,, ..	Fir, spruce..	·512	10,100	6,500	1,490
,, ,, ..	Pine, white .	·432	..	..	1,229
,, ,, ..	,, yellow	·508	..	5,300	1,185
,, ,, ..	,, red ..	·576	12,000	5,400	1,200
,, ,, ..	,, ,, ..	·657	14,000	7,500	1,530
,, ,, ..	Larch ..	·543	8,900	3,200	1,330
,, ,, ..	,, ..	·556	10,200	5,500	1,660
,, ,, ..	Oak ..	·777	10,000	6,400	1,600
,, ,,	,, ..	·934	19,000	10,000	1,690

Comparative Breakage Weight of Actual Pit Props.

Authority.	Kind and State of Wood.	Number and size of props.			Breakage Weight per sq. inch.		
		No. of	Length.	Diameter at top end.	Maximum.	Minimum.	Average of all.
			Inches	Inches.	Lbs.	Lbs.	Lbs.
Prof. H. Louis, 1897..	Baltic red and whitewood props mixed:—						
,, ,, ,, ..	Partly seasoned..	2	12	3·55	4077	4010	4043
,, ,, ,, ..	,, ,, ...	6	24	4·19	3942	2822	3199
,, ,, ,, ..	,, ,, ...	14	35·9 to 37	3·33	3606	2845	3157
,, ,, ,, ..	Well ,, ...	11	36	3·34	4749	2688	3721
,, ,, ,, ..	Partly ,, ...	6	48	4·98	4838	3360	4117
,, ,, ,, ..	Well ,, ...	6	48	5·12	5687	3485	4310
,, ,, ,, ..	,, ,, ...	12	58·8 to 67	3·98	5555	3562	4637
	Average of the set	57	42·1	3·93	5687	2688	3835
,, ,, ,, ..	Parly seasoned, Creosoted	14	35·9 to 37	3·34	3270	2442	2890
,, ,, ,, ..	Well ,, lightly Creosoted	11	36	3·39	5197	3203	4126
	Average of the set	25	36·2	3·36	5197	2442	3434
,, ,, ,, ..	Partly seasoned, Salted	6	48	5·37	3920	2643	3275
,, ,, ,, ..	Well ,, ,, ...	6	48	5·25	4695	2968	3835
	Average of the set	12	48	5·31	4695	2643	3555

COMPARATIVE BREAKAGE WEIGHT OF ACTUAL PIT PROPS.—*Continued.*

Authority.	Kind and State of Wood.	Number and size of props.			Breakage Weight per sq. inch.		
		No. of	Length.	Diameter at top end.	Maximum	Minimum.	Average of all.
			Inches.	Inches.	Lbs.	Lbs.	Lbs.
	LARCH props:—						
Prof. H. Louis, 1897..	Partly seasoned, Whitewood	6	48	4·80	4592	3539	4122
,, ,, ,, ..	Query ,, ...	12	48	3·63	4704	2240	3311
,, ,, ,, ..	Well ,, ...	6	48	4·72	4657	2598	3604
	Average of the set	24	48	4·195	4704	2240	3587
,, ,, ,, ..	Partly seasoned and Salted	6	48	4·82	4457	2912	3780
,, ,, ,, ..	Well ,, ,, ...	6	48	4·62	4265	3530	3774
	Average of the set	12	48	4·72	4457	2912	3777
	SCOTCH props:—						
,, ,, ,, ..	Green and full of sap	6	48	4·45	3069	1501	2303
,, ,, ,, ..	Partly seasoned	6	48	3·39	3114	2016	2583
,, ,, ,, ..	Well ,, ...	6	48	3·07	3024	2352	2677
	Average of the set..	18	48	3·64	3114	1501	2521
,, ,, ,, ..	Partly seasoned, Creosoted	11	48	3·92	3517	1725	2614
,, ,, 1899..	OAK props, 21 to 43 inches:—						
,, ,, ,, ..	Ordinary..	7	38	3·67	2912	1702	2186

BREAKAGE WEIGHT OF ACTUAL PIT PROPS, 39 TO 99 INCHES IN LENGTH, AND AVERAGE DIAMETER A LITTLE LESS THAN 5 INCHES, AVERAGE AREA 20 INCHES, AT KÖNIG COLLIERY, NEUNKIRCHAN, SAIAR, WITH TIMBER SAWN AFTER IT WAS FELLED.

Authority.	Kind of Wood.	Green, newly felled, with bark on.		5 months after felling, with bark on.		Dried, Temp. 149° Fahr. Without bark.	
		Specific Gravity.	Breakage Weight per square inch.	Specific Gravity.	Breakage Weight per square inch.	Specific Gravity.	Breakage Weight per square inch.
			Lbs.		Lbs.		Lbs.
Ch. Dütting, 1898	Beech	1·084	3243	1·094	3570	·915	3627
,, ,, ...	Fir	·885	2802	·845	3044	·656	3385
,, ,, ...	Pine..	·984	2631	·917	2716	·647	2958
,, ,, ...	Oak	1·235	2475	1·050	2133	·825	2958

Modulus of Elasticity of Pit Woods.

Authority.	Kind of wood.	Weight of a cubic foot.	Modulus of Elasticity per square inch.			
			Increase or decrease in inches per foot in length with a stress of one ton per square inch.	Height of the column of wood.	Weight of the column of wood.	Weight each square inch will bear without permanent alteration in length.
		Lbs.	in.	Feet.	Lbs.	Lbs.
Dr. Thos. Young, 1807	Beech	53·0	..	8,000,000	....	.
,, ,,	Elm	49·9	..	8,000,000	....	..
,, ,,	Fir	34·9	..	10,000,000	....	..
,, ,,	Oak	61·8	..	5,060,000	....	..
Templeton, 1847	Ash	46	..	....	1,525,500	..
,, ,,	Beech	48	..	...	1,316,000	..
,, ,,	Elm	44	..	....	1,343,000	..
,, ,,	Fir, Memel	34	..	....	1,957,750	..
,, ,,	,, Scotch	33	..	....	951,750	..
,, ,,	Larch	31	..	....	1,363,500	..
,, ,,	Oak	50	..	....	1,714,500	..
Molesworth, 1899	Ash	43 to 47	·0164	....	1,640,000	3796
,, ,,	Beech	43	·0220	..	1,345,000	3113
,, ,,	Elm	34 to 36	·0201	....	1,340,000	1500
,, ,,	Pine, White	27 to 34	·0244	....	1,100,000	2300
,, ,,	,, Red.	36 to 41	·0145	....	1,850,000	2930
,, ,,	Larch	34 to 35	·0251	....	1,074,000	2480
,, ,,	Oak	48 to 58	·0189	..	1,420,000	3170

The CHAIRMAN: Before proposing a formal vote of thanks to Mr. Dickinson for his interesting paper, I should be glad to hear any remarks bearing upon it from any member.

Mr. HENRY HALL: I have listened with very great interest to the paper. I expected it would be interesting when I knew that Mr. Dickinson was going to read it. The chief point he seems to have brought before us is the strength of different timbers. So far as I could glean from the paper, all the strengths he has given depend upon actual perpendicular pressure. But in mines, I imagine the weight hardly ever comes in that way; and it seems to me of more importance that the timber you select should be able to bear a great bending pressure rather than a great crushing weight. There are hardly any mines which are perfectly horizontal, and wherever the mines are not horizontal the crushing does not come in a vertical fashion. The men, some of them perhaps, may set their props at right angles to the dip, but the majority of props, where the angle is not very great, will not be set at the right angle of the dip, and for that reason the pressure never comes in the way that these experiments have been carried out. Mr. Dickinson gives us some of Professor Louis's deductions from experiments that he made. He makes rather a remarkable statement, which is, I think, to the effect that whatever the length of the prop, up to a certain point, it will bear the same crushing weight. Well, as far as mine timber is concerned, I do not think any of us would be willing to accept that view; and perhaps Professor Louis means that if you keep the pressure actually vertical it does not matter what length the prop is. But in mining you know if you were to set props three inches in diameter and seven or eight feet high it would be ridiculous. It is rather difficult to criticise a paper on just hearing it read; perhaps at a future time we

may have an opportunity of saying more about it. I did hope that Mr. Dickinson was going to become an advocate of systematic timbering. To my mind the quantity of timber put up is much more important than the strength of it. So far as I have observed, in the majority of the accidents, the roof has come down where there has not been sufficient timber; and I think it very seldom happens that timber breaks in these cases. The accident generally occurs where there is a scant supply of timber, or the moving weight upsets the timber that is standing. Mr. Dickinson mentioned that the Government had the idea of making some rule about the drawing of timber. The Government also has the intention of bringing before colliery owners the question of systematic timbering. It has already been applied to some extent in Lancashire, and I think with very great success. I was speaking only a day or two ago to a mine manager who has applied it, and has had it in operation six or seven years, and he spoke very highly of it. He says he can see for himself that there is a reduction in the number of accidents where it has been brought into force; and not only so, but he says it gives the officials very much more power over the men. When the men have the timbering in their own hands they will stand and argue with the fireman as to whether it is or is not needed, but if the rule is that timber shall be so far apart, and no further, the fireman has a proper hold upon the men. Of course it is an experiment to some extent, but to my mind it would save a great number of accidents and add very much to the discipline of the colliery.

Mr. Harrison: I can bear out from my experience what has been said as to the need of systematic rules for timbering. I believe systematic timbering would save many lives in the pits. It needs of course a great deal of consideration, and

the employer will have to exercise all his wisdom in the study of it. Probably there are no two seams which will bear the application of the same rule; but that some rule is wanted I am certain. Much might be said in favour of systematic timbering, but many people are writing against it, professedly, whilst the thing they are really writing against is uniform timbering, that is never more and never less than the distance specified as a maximum. Well I think the more a man knows about a mine the less will he want uniform timbering, in every case. Under a special rule if you found a collier had his timber six or seven feet from the face, when you knew it was not safe at a greater distance than five feet, you would have the means of bringing him to account, if he disregarded your warning, providing the rule specified 5 feet as the maximum. Such a rule would strengthen the hands of the fireman. Though he can point to no apparent weakness yet he can point to the rule, and insist that the timbering shall not be further back than the prescribed distance. On these grounds systematic timbering is in my view the best. Mr. Dickinson's paper is a long one and contains much valuable information. I shall be glad to read it at my leisure. The only thing which disappoints me is the absence of all reference to systematic propping.

Mr. Dury Mitton: I agree with what Mr. Hall said about Mr. Dickinson's paper. It is a most interesting paper, but it is really too much to discuss upon merely hearing it read. I think we should defer the discussion till another meeting after the paper has been printed.

Mr. James Tonge: I have listened with great pleasure to Mr. Dickinson's paper. It always gives me pleasure to listen to Mr. Dickinson; he never touches a subject without

throwing some light upon it. I do not agree with Mr. Hall and Mr. Harrison in thinking that Mr. Dickinson should have introduced the subject of systematic timbering. It may be all right for present-day inspectors to speak upon it whenever they think proper, but for a gentleman in Mr. Dickinson's position it is a different matter. I did not myself expect that he would take up the attitude they have done. I think Mr. Dickinson has given us a very interesting and comprehensive resume of the opinions of eminent men as to the strength of timber and how to preserve them for mining uses. I did think that he would have gone a little further and dealt with the question of the setting of both props and bars; indeed I thought that that would form the main subject of his paper. However, I feel sure when we come to read it that we shall value it as a most interesting compilation of the principal things that have been written on the subject of timber for a very long time—in fact during the whole period of mining. With regard to systematic timbering. I happen to be pretty well aware of the opinions of a considerable number of managers and they are not so much opposed to the principle of systematic timbering; but they do not want, as they express it, "to put their necks into a noose." Some of them think it means uniform timbering, to which they do object.

The CHAIRMAN: It has been suggested that the discussion should be adjourned, and if it is agreeable to Mr. Dickinson that, I think, would be a wise course to take.

Mr. DICKINSON: Quite so.

The CHAIRMAN: There is a great deal in the paper that is deserving of careful study. An old man once said to me when I asked why he did not do so and so:—"There's a deal of things belong to everything." The longer I live

the truer I find it. There is more involved in systematic timbering than appears on the face of it, and anyone who takes up the question with a view to adopting it will find it beset with many collateral issues. However, I will not say more to-day. I move that our best thanks be given to Mr. Dickinson for his able and interesting paper.

The motion was seconded by Professor BOYD DAWKINS, and carried unanimously.

Mr. DICKINSON, in replying said: I am much obliged to you, gentlemen, for this vote of thanks and also for the kind expressions of some of the gentlemen who have given us their views in the course of the discussion. In the discussion so far as it has gone Mr. Hall alone has touched, and that incidentally, on the strength of timber. He endeavoured to reconcile the discrepancies which exist now in the accounts of the different tests. As regards the other point, to which all the speakers have addressed themselves, it is only incidentally alluded to in the paper, and that is in very few words—the setting is "to some degree enforced." The main point to which I invited attention as to the setting of props had relation to the two different principles which may be noticed by any person who has opportunities of comparing the practice in one colliery with those in others, and that is as to whether the props should be all set in the direct axis of the pressure, or whether there should be diversity in the slope of the props. Not one of the speakers has said a word on that point, to which attention was specially requested in the paper. I purposely avoided going into what might be considered a controversial topic; nor did I consider it necessary to go into all the little methods common to every person who is accustomed to setting props, particularly now when we have so many props coming to collieries cut in certain lengths, which

have to be adapted to the height of the workings. These are not in the paper. The points to which attention is requested are the differences in the tests of strength, and also in the two principles of setting the props; and if the discussion should be adjourned I hope some gentlemen, after reading the paper, will kindly address themselves to those two points.

It was then resolved that the discussion should stand adjourned.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIII. VOL. XXVI. SESSION 1899-1900.

The ORDINARY MEETING of the Members was held on Tuesday, December 12th, 1899, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Professor W. BOYD DAWKINS, in the absence of the President, in the Chair.

THE PARIS CONGRESS.

Mr. STIRRUP reported that he had received, a few days ago, a letter from Madame Brongniart, the widow of our lately deceased Honorary Member, in response to the receipt of the June part of the Transactions of the Society, wherein is published a notice of the death of Mr. Charles Brongniart, and a sketch of his scientific work. Madame Brongniart writes that she wishes to thank the Members of the Society in her own name and that of her children for this appreciative souvenir of her husband.

Mr. STIRRUP also announced that the date of the Meeting of the International Geological Congress at Paris, next year, had been fixed for August 16-28. Excursions are being organized to all the points of geological interest throughout the whole of France, to take place *before*, *during*, and *after* the Congress.

HOWAT'S LATEST SAFETY LAMP.

Exhibited and Described by Mr. J. G. PATTERSON.

(Communicated by Mr. JOSEPH DICKINSON, F.G.S.)

Howat's latest Safety Lamp has been designed to burn paraffin oils and to prevent the tendency of the oil by reason of the heat of the lamp to rapidly vaporise and pass up into the flame chamber in excessive quantities, which cause the light to smoke or be extinguished by internal explosion. The details may be thus described. (*See Diagram.*)

A. Is the outer shield.

B. Gauzes.

C. Glass.

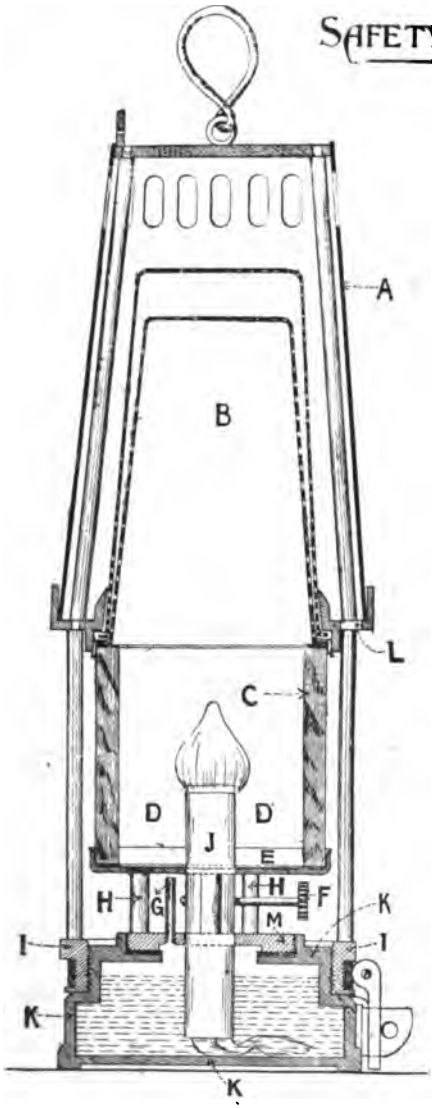
J. Wick tube, which is carried from flame chamber D to within $\frac{1}{8}$in. of the bottom of oil cup K.

E. Ring to support glass and gauzes, and is permanently connected to screwed flange M by standards H, which maintains air space between oil cup K and flame chamber D, with a minimum of heat conducting area.

F. Milled disc for raising or lowering wick.

G. A small tube which opens into the interior of the oil cup and to the atmosphere, and constitutes a vent for any vaporised oil.

To Illustrate Howats Latest Safety Lamp.



I. Ring of lamp into which oil cup is screwed, carrying rings E and M, which support glass and gauzes. It will be noticed that the joints at each end of the glass do not depend on the good fit of a thread for being safe. The isolation of the flame chamber from the oil reservoir whereby an air space is formed between them and air allowed to circulate in such space with a much longer wick tube, enables the lamp to burn paraffin with absolute safety.

Messrs. Baxendale and Co., who are the makers of this lamp, have erected at their Miller Street Works, Manchester, a Miner's Safety Lamp test. Members of the Society are invited to call and inspect this. Howat's latest safety lamp can be seen successfully withstanding an explosive current of 50ft. per second, and also burning in a temperature of 300° F. with paraffin oil of 110 flash point as the illuminant.

The illuminating power of this lamp has been measured at the Gaythorn Gas Works, Manchester. Taking a standard Marsaut as 1. Howat's latest safety lamp gave 1·85.

Mr. Dickinson moved that the thanks of the meeting be given to Mr. Patterson for his paper. He said: I have examined this lamp beforehand, and the points which, to me, are new in it are the flame chamber being isolated from the oil chamber, with an escape outlet, adapted for burning paraffin with safety, and an electric wire for re-lighting. In other respects the lamp appears to be the same as the Marsaut lamp, and giving 50 per cent. more light than the ordinary safety lamp is a very valuable adjunct.

Mr. Stirrup seconded the vote of thanks, which was passed unanimously.

Mr. Stirrup asked if the lamp had been shown at Wigan.

Mr. PATTERSON: Some of the mining managers of this County have seen the lamp.

The CHAIRMAN: Has it been used in any mine?

Mr. PATTERSON: No, there are only sample lamps in use. It is quite new.

Mr. HENRY HALL: The use of paraffin in miners' lamps is not at all new. I have seen it used in ordinary safety lamps for the last five or six years. Messrs. Naylor, of Wigan, have a lamp something like this, in which they burn paraffin. What strikes me about this—if it has a weak point at all—is that the little knob inside would not last long. It seems liable to be knocked off.

Mr. PATTERSON: It is very strong and no harm can be done to it, except on purpose.

Mr. HALL: I have carried paraffin lamps underground several times. They do not seem to keep the paraffin from leaking, the lamp gets wet at the bottom.

Mr. PATTERSON: In the lamp now shown that difficulty is got over. Any leakage of oil, or sweating, is outside, away from the flame.

Mr. HALL: Only it wets the hand.

Mr. PATTERSON said there could be no danger of explosion because it was not possible for any oil, by reason of leakage or sweating, to get within the lamp chamber.

Mr. DICKINSON said it was true, as Mr. Hall had pointed out, that the use of paraffin in safety lamps was not new; Mr. Teale had produced such lamps for many years. But Howat's lamp has some distinctive features, which he had already pointed out. He had never before seen a lamp with the chamber isolated, as in this one.

NOTES ON THE WORKING OF COAL MINES UNDER SEA; ALSO UNDER THE PERMIAN FEEDER OF WATER, IN THE COUNTY DURHAM.

By Mr. Thomas Bell, M.E., Scarborough.

Read by Mr. Joseph Dickinson, F.G.S.

My object in submitting the following remarks is to give an idea of the depth and extent to which the Coal Mines have been worked under the sea off the coast of Durham and Northumberland, and inland under the heavy feeders of water contained in the sand bed found beneath the Magnesian Limestone in the County of Durham, known as the "Sand Feeders," without bringing the water down into the workings except in two or three cases which was done under exceptional circumstances, and is hereafter referred to.

What is understood in this district by the term "Sand Feeder" is the water contained in a portion of the strata (the Lower New Red Sandstone) underlying the Permian system, and overlying the true coal measures.

The thickness of this sand and the quantity of water it contains vary considerably at the different winnings where it has been sunk through. At the Seaton pit near to Seaham Harbour the sand at one side of the shaft was three feet, while at the opposite side it was fifteen feet in thickness.

The sand is incoherent and seldom cemented together sufficiently to form a sandstone, and has been the source of much difficulty and expense in sinking through it into the coal measures, notably at Marsden, Wearmouth, Ryhope, Seaham, Murton, and several other places.

To the south and west of the district where the limestone is much increased in thickness and the lower portion being

of a hard compact texture, this sand gave off comparatively small quantities of water, as at South Wingate, Trimdon, &c. At the latter place it was passed through nearly dry and was divided into two distinct beds, one white, the other a bright yellow sand, quite friable, and could be easily crushed in the hand.

The portion of the Great Durham Coalfield which I propose to deal with adjoins the sea between the Tyne and Hartlepool on the east and rising gently westward abuts against the Magnesian Limestone with its lower seams on the west, thus if we strike a line from Sunderland on the north-east (where the lower seams have not yet been proved and are probably not workable, but I estimate the depth to the Brockwell to be about 2,200 feet) to Middridge on the south-west, a distance of about 22 miles, we find it has risen to within 377 feet of the surface (the former place being 100 feet, and the latter 400 feet above sea level,) all the upper seams, down to the Busty, having been apparently denuded.

The Magnesian Limestone rests unconformably on the coal measures, near to Hartlepool some of the seams have been proved to rise towards the south terminating against the bottom of the newer rocks.

The Brockwell or lowest workable seam passes at its outcrop under the Magnesian Limestone a little east of Shildon on the south-west of the Durham Coalfield, dipping to the north and west at an angle of about four degrees.

From the Cap of Magnesian Limestone at Tynemouth to the extremity of the range at Castle Eden, the beds of limestone become more depressed or have irregular dip from north to south. At Tynemouth the bottom of the limestone is 50 to 60 feet above sea level, whereas at Castle

Eden Colliery, which is a considerable distance inland, the bottom of the limestone is 270 feet below the level of the sea.

The regularity of the basin like form towards the Southern margin of the Durham Coalfield is somewhat interrupted by a fault known as the "Butterknowle Dyke" which ranges in a W.S.W. and E.N.E. direction, commencing in Teesdale and terminating, or running into the sea at the Pier Head at Hartlepool, depressing the strata on the south to the extent of from 600 to 700 feet, and bringing in the upper measures with all the coal seams from the 5/4 (Five Quarters) downward under the Permian rocks at Leasingthorne, Black Boy, Eldon, and a few other Collieries.

To the south of this fault the strata dip rapidly towards the N.N.W., thereby bringing the lowest seams in contact with the overlying Permian formation, and ultimately the Millstone Grit itself from its visible outcrop near Heighington, eight miles N.W. of Darlington.

Two "Whin Dykes" also run through the county from west to east, both apparently commencing at or near to Middleton-in-Teesdale where the great "Whin Sill" is exposed.

The Northernmost, or as it is commonly called the "Hett Whin Dyke," runs nearly parallel with and to the north of the "Butterknowle Dyke" above alluded to, and is last seen on the sea beach below Easington, a little to the south of the New Winning.

The Southernmost, or as it is commonly called the "Cockfield Whin Dyke," runs a little more to the south, crossing the river Tees below the village of Yarm into the North Riding of York, where it is extensively worked for road metal at Great Ayton (under the shadow of the far

famed "Roseberry Topping"), at several places along the Esk Valley, at Grosmont, and several other places en route, and finally disappears in the sea at Cloughton, about five miles north of Scarborough.

All these "Dykes" are shown on the accompanying plan.

Mining engineers of former times were of opinion that the bottom of the Durham coal basin would be found about the coast line; subsequent explorations have however proved this not to be the case, as the seams worked for a mile under the sea are found to be still dipping eastward.

There are only two Collieries which have worked coal under the sea in the Durham Inspection district, viz.:—Ryhope and Seaham, and these only in the Maudlin and Hutton seams.

The usual system of working the under-sea coal is the same as practiced in working the inland coal, viz.:—by "bord and pillar," and occasionally a little "long-wall." In each case the whole of the coal is taken out and the roof allowed to fall, except that a barrier of about 30 yards of coal is left next to all slip faults of importance as a safeguard to support the broken strata.

In numerous instances where goaf has been extensively formed in working under the limestone, there has been considerable shrinkage and damage done to the surface and buildings, yet the intervening strata below the sand has been sufficient to keep up this water, which might be termed an enormous natural subterranean reservoir, and this, to my mind, ought to allay any doubts or fears of an inundation while working the under-sea coal at such depths as are hereafter mentioned.

I am of opinion that it is safer at such depths to take out all the coal and allow the strata to gradually settle down,

which it will do without causing fractures to any extent, whereas if from 40 to 60 per cent. of the coal be left, it follows that it is insufficient to support the superincumbent strata, while it necessarily prevents its falling, and consequently sets up a "creep," which causes an uneven subsidence of the strata and is liable to cause breaks or cracks to fissures which might possibly communicate with feeders of water, especially in broken ground or in the neighbourhood of faults.

There are at present no under-sea coal workings south of Seaham Harbour, but preparations are being made to sink pits on the Seaham estate, about a mile to the south of the Harbour, for the purpose of working under-sea coal only, the first sod for which was cut on 26th August, 1899.

The Easington Coal Co. Ltd. have already commenced to sink three shafts—two of them to be 20 feet and one 17 feet in diameter finished size—to the Harvey seam. These pits are situated in a direct line between the village of Easington and the coast, about 500 yards from high water mark, and in close proximity to the new coast line of railway now in course of construction, and about three miles south of the new Seaham Docks.

It is expected that the depth to the bottom of the limestone will be about 85 fathoms, including about eight fathoms of sand, and that the Harvey seam will be reached at about 217 fathoms from the surface.

When the coast line of railway between Seaham and Hartlepool is made, and extension and deepening of the Seaham Docks is completed, there is every probability that other large Collieries will be sunk at various places along the coast southward, which will not only open out a large area of under-sea coal (probably from eight to ten miles between

north and south, but will enable them to work a large area of inland coal (about two miles in width) which cannot at present be economically worked to the dip of the existing Collieries. This large virgin coalfield between Seaham and Hartlepool is already being prospected, and when opened out will find a convenient shipping place at the above-mentioned docks, where vessels up to 5,000 tons burden may then be loaded.

Proceeding northward along the coast from the River Wear, I understand that at Monkwearmouth and Marsden (Whitburn) Collieries the workings have reached a distance of about three-fourths of a mile under the sea; but I am unable to say if they have removed any pillars or worked any longwall in that direction.

North of the River Tyne, both North Seaton and Cambois Collieries are working coal under the sea to about the above-mentioned distance and at a depth of 60 fathoms, in a seam varying from four feet to six feet in thickness.

At Cambois they are working longwall, and drive headings 100 yards in advance of the working face to ascertain the existence of any fault or break in the strata.

They leave 20 yards of coal next to faults whose throw exceeds six yards or cheeks are more than two feet apart. The main roads are protected by barriers of coal 50 yards wide, and side roads by 20 yard barriers; such barriers may be extracted when no longer required.

For illustration of what has been worked under the limestone and sand feeders, I herewith give particulars of some of the principal Collieries, as near on a line as possible, from Monkwearmouth on the north to Kelloe and Garmondsway on the south, then east of Castle Eden Colliery, being all situated in the County of Durham.

The annexed sections are taken from the "Sections of Strata in Northumberland and Durham," published by the North of England Institute of Mining Engineers. They show the thickness of strata from the surface to the bottom of the above-named feeders of water; also the proximity of the various coal seams underlying.

The marl slate is not mentioned in any of the northern sections of strata that I have met with; but what I understand to be the marl slate, and have placed it in that position, is the mention in some of the sections of the "blue limestone" or "blue metal," immediately overlying the the sand. It is occasionally called the "fish bed," but more frequently omitted altogether.

MONKWEARMOUTH COLLIERY.

100 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			117	0		
Limestone and Marl			199	7		
Marl Slate (Fish Bed)			8	10		
Sand (Lower New Red)..			5	0		
To bottom of limestone and sand feeders ..					330	5
Further to the supposed 5/4 seam but is not so named in the section	4	6	749	9	1,080	2
Further to the Main Coal seam	2	11	415	9	1,495	11
„ Maudlin seam..	5	6	98	1	1,594	0
„ Low Main seam (supposed)			—	..	—	
„ Hutton seam..	4	6	131	0	1,725	0
„ Harvey seam..	3	1	178	4	1,903	4
Estimated to Busty seam..			150	0	2,053	4
„ Brockwell			150	0	2,203	4

The Maudlin and Hutton seams have been extensively worked at this Colliery for many years, and both seams have been goafed in a vertical line over many acres inland. The upper and lower seams do not appear to have been touched.

Silksworth Colliery.

240 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			4	0		
Limestone and Marl			311	6		
Marl Slate			2	6		
Sand			7	0		
To bottom of the feeders					325	0
Further to the supposed 5/4 seam	4	2	794	7	1,119	7
„ Main Coal	—		—		—	
„ Maudlin	5	9	499	2	1,618	9
„ Low Main	3	3	3	5	1,622	2
„ Hutton	4	4	118	4	1,740	6

This Colliery does not join the coast, but has been extensively worked inland in the Maudlin and Hutton seams, both being goafed in a vertical line over a considerable area.

None of the other seams have yet been touched.

There are three upper seams mentioned in the section and much doubt exists as to their identity: The first is found at a depth of 680 feet from the surface and is 3 feet 5 inches in thickness, another at 798 feet which is 5 feet 1½ inches in thickness, and the above mentioned or supposed 5/4 seam which is met with at 1,119 feet 7 inches from the surface.

Ryhope Colliery.

195 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			19	0		
Limestone and Marl			206	5		
Marl Slate			1	1		
Sand (2,600 gallons of water per min.)			96	6		
To bottom of the feeders			..	..	323	0
Further to the 5/4 seam ..	4	2	650	4	973	4
„ Main Coal ..	4	6	254	0	1,227	4
„ Maudlin	7	2	300	8	1,528	0
„ Low Main ..	2	11	57	9	1,585	9
„ Hutton . ..	3	9	44	4	1,630	1

A very considerable area of both Maudlin and Hutton seams have been worked and goafed in a vertical line inland at this Colliery. The pillars left are 40 by 30 yards.

The workings in the Maudlin seam have been extended under the sea for over a mile from low water mark, and over 400 acres of goaf have been formed. The estimated depth from the bottom of the sea to the Maudlin seam is about 1,830 feet.

The under-sea workings are still progressing in the Maudlin, but nothing has yet been done under the sea in the Hutton seam.

The magnetic line of dip at Ryhope is found to be S. 75 E., and the gradient about 1½ inches to the yard, but the last 400 yards driven in the Maudlin the seam has been rising at about ½-inch to the yard. This would appear to be a mere local uprising until a fault has been met with but not yet proved; all the surrounding circumstances would indicate that the fault is a dipper to the east.

Seaham Colliery.

220 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			56	0		
Limestone and Marl			448	9		
Marl Slate			4	2		
Sand (over 6,000 gals. of water per min.)			6	0		
To bottom of the feeders.. ..			..	..	514	11
Further to the 5/4 seam ..	5	3	628	5	1,143	4
„ Main Coal ..	6	1	166	0	1,309	4
„ Maudlin ..	5	0	51	10	1,361	2
„ Low Main ..	5	2	66	6	1,427	8
„ Hutton ..	4	8	100	4	1,528	0
„ Harvey ..	2	10	160	0	1,688	0
„ Busty, including 3 bands of 2ft. 8in...	6	7	109	0	1,797	0

A very large area of coal has been worked inland at this Colliery in both Main Coal, Maudlin, Low Main, and Hutton seams, and in several places all the four seams have been goafed in a vertical line.

The workings in the Maudlin seams have been extended under the the sea for about one mile, and about 85 acres of goaf have been formed; there has also been 12 pillars, each 40 by 30 yards, taken out in the Hutton seam under the Maudlin goaf. The under-sea workings are still progressing, and the estimated depth from the bottom of the sea to the Maudlin is 1,830 feet.

The Magnetic line of dip is S. 58. E., and the gradient about 1 in 18. Here also while driving in the No. 2 pit, Hutton seam, about the last 400 yards the seam has been rising at the rate of 2 to 2½ inches to the yard, this would

also appear to be a local uprising of the strata which is no doubt due to their approaching the same fault as met with on this line at Ryhope Colliery.

Murton Colliery.

357 feet above Sea Level.

	Ft.	In	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			33	0		
Limestone and Marl			417	1		
Marl Slate			2	0		
Sand, (West pit, 26ft.; East pit, 34½ft.; Middle pit, 27 ft. 8 in.			27	8		
To bottom of the feeders.. ..			..	..	479	9
Further to the 5/4 seam ..	4	9	582	3	1,062	0
„ Main Coal ..	6	2	157	2	1,219	2
„ Maudlin ..	1	1	—	..	—	
„ Low Main ..	4	7	143	2	1,362	4
„ Hutton ..	6	2	108	2	1,470	6
„ Harvey ..	2	8	154	10	1,625	4

The Low Main and Hutton seams have been extensively worked, and goafed in a vertical line over a very large area. The 5/4 and Main Coal seams have been only partially worked.

This was one of the most difficult and expensive winnings on the north east coast, the feeders of water encountered in sinking through the limestone and sand were estimated at over 10,000 gallons per minute.

A very interesting paper on the winning of this colliery by the late Mr. Edward Potter (the Viewer) will be found at page 43, Volume 5, of the Transactions of the North of England Institute of Mining Engineers.

Haswell Colliery.

460 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit	..	..	18	7		
Limestone and Marl	..	..	259	11		
Marl Slate	..	..	24	8		
Sand	..	..	—			
To bottom of the feeders	..	..	..	..	303	2
Further to the 5/4	3	6	246	2	549	4
„ Main Coal, 3ft. to 4ft.	..	..	98	1	647	5
„ Maudlin	—	..	—	..	—	
„ Low Main	3	7	155	7	803	0
„ Hutton	5	5	119	0	922	0

There was no sand met with in sinking the present Haswell shafts, but in a previously attempted winning a little to the north, at a depth of 38 fathoms a bed of sand 114 feet in thickness was met with, which contained such a large quantity of water that the sinking had to be abandoned.

All the above-mentioned four seams have been extensively worked at this Colliery, and large areas of goaf have been formed in a vertical line in all seams.

The 5/4 seam which is nearest to the limestone has been extensively worked by the longwall system over the other goafs, but none of the feeders have been tapped.

Wheatley Hill Colliery.

410 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit	..	..	72	0		
Limestone and Marl	..	..	288	0		
Marl Slate	..	..	1	8		
Sand	..	..	18	0		
To bottom of the feeders	..	..	..	..	379	8

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Further to the 5/4 seam ..	4	0	279	1	658	9
„ Main Coal ..	3	4	91	3	750	0
„ Maudlin ..	—		—		—	
„ Low Main ..	3	0	122	0	872	0
„ Hutton ..	3	2	120	3	992	3
„ Harvey ..	3	8	147	11	1,140	·2
„ Busty.. ..	4	0	36	2	1,176	4

In sinking through the sand it was found to be soft and watery, but did not run in the shaft.

The 5/4 and Main Coal seams have been largely worked at this Colliery, and both goafed in a vertical line. They are now extending the Harvey seam workings under the other seams.

THORNLEY COLLIERY.

500 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			18	0		
Limestone and Marl			135	0		
Marl Slate			1	6		
Sand			36	0		
To bottom of the feeders			..	..	190	6
Further to the 5/4 seam ..	3	5	316	3	506	9
„ Main Coal ..	2	9	107	8	614	5
„ Maudlin ..	—		—		—	
„ Low Main ..	3	0	125	0	739	5
„ Hutton ..	3	2	126	2	865	7
„ Harvey ..	3	8	128	6	994	1

This Colliery has been extensively worked in all the seams.

Over the greater part of the Royalty three of the seams have been worked and goafed in a vertical line.

In one part of the Royalty for over more than 100 acres four of the seams have been worked and goafed in a vertical line.

And in several small parts of the mine all the above-named five seams have been worked and goafed in a vertical line without bringing down any of the sand or limestone feeders of water.

KELLOE (EAST HETTON) COLLIERY.

425 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			7	2		
Limestone and Marl			150	0		
The Sand is not mentioned in section.						
To bottom of the feeders			..	..	157	2
Further to the 5/4 seam ..	4	6	184	8	341	10
„ Main Coal ..	4	7	45	6	387	4
„ Low Main ..	2	4	148	10	536	2
„ Hutton ..	2	10	135	8	671	10
„ Harvey ..	3	6	136	11	808	9

This Colliery is about 2½ miles west of the before mentioned Trimdon Colliery, and although there was no sand met with in the sinking there were heavy feeders of water from the limestone.

GARMONDSWAY COLLIERY.

402 feet above Sea Level.

	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit	27	6		
Limestone and Marl	275	6		
No mention of Sand in section.				
To bottom of the feeders	..	..	303	0
Strata	86	2	389	2
Coal Seam (worked and originally named the 5/4, but proved to be the Harvey)	4	10	394	0
Strata	36	4	430	4
Coal, 4in. band in middle (not worked, originally named Main Coal, but proved to be the Busty)	4	3	434	7

This Colliery is situated on the Kelloe Royalty and is about 2,500 yards to the south and west, and not far from the "Butterknowle Dyke" or Southern outcrop.

As previously mentioned there was not a large quantity of water met with in sinking the pits in the Trimdon and Kelloe district, but it was found necessary to line out the shafts with metal tubbing to the bottom of the Permian.

On a reference to the accompanying sections of strata it will be found that at the Kelloe or East Hetton Colliery, the 5/4 seam is worked at a depth of 185 feet below the sand feeders. This being the northernmost of this range of pits, there was a larger quantity of water met with in sinking, apparently from the limestone, as the sand is not mentioned in the section.

At Trimdon Grange Colliery the 5/4 seam is worked at a depth of 190 feet. At Trimdon it is worked at a depth of 60 feet, and at Deaf Hill at a depth of 133 feet below the sand feeders. The lower seams are also worked at all these Collieries, most of them in a vertical line.

It will be seen on referring to the plan that these Collieries are all pretty close together, Garmondsway being the furthest to the south.

The surface at Kelloe is 23 feet above the surface at Garmondsway pit. The 5/4 seam at Kelloe is found at a depth of 342 feet from the surface, rising rapidly to the south, and is cut off under the Permian before reaching Garmondsway; all the other seams are rising at the same angle, as delineated on the accompanying sketch.

At Garmondsway there is a seam of coal 4ft. 10in. thick found at a depth of 394 feet from the surface, which was the only one worked, and was commonly called the 5/4 seam, but has proved conclusively to be the Harvey seam.

There is another seam of 4ft. 3ins., with 4ins. of band in the middle, found at a depth of 430 feet from the surface

which was not worked, and was usually thought to be the Main Coal seam, but has proved to be the Busty seam, both dipping rapidly towards Kelloe Colliery.

There was always a diversity of opinion as to the identity of these seams, being the first workable seams met with under the Permian.

The Garmondsway pit, from the great inclination of its seam and the quantity of water met with, was not much worked, and it has been abandoned for a great many years.

During recent years the Harvey seam has been extensively worked at the Kelloe Colliery, and, as previously described, it has been proved beyond doubt that the upper or 4ft. 10ins. seam worked at Garmondsway Colliery is the Harvey seam, the Kelloe pit's workings having approached to within a distance of 200 yards of the old Garmondsway pit workings.

The lower or 4ft. 3ins. seam proved at Garmondsway has not been sunk to at the Kelloe pit, but it is undoubtedly the Busty seam.

The enclosed sketch gives a fair view of the position of the various coal seams and how they are cut off under the Permian from Kelloe towards Garmondsway, and may be taken as a fair representation of the cutting off of the whole of the coal seams and measures along the southern edge of the Durham Coalfield.

TRIMDON GRANGE COLLIERY.

500 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			65	8		
Limestone and Marl..			181	4		
Marl Slate (evidently not noticed) ..			—			
Sand			4	2		
To bottom of the feeders					251	2

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Further to the 5/4 seam ..	3	9	108	11	360	1
„ Main Coal ..	4	9	90	6	450	7
„ Maudlin	—		—		—	
„ Low Main ..	3	6	132	7	583	2
„ Hutton	1	10	132	6	715	8
„ Harvey.. ..	3	7	141	11	857	7

The 5/4 Main Coal, Low Main, and Harvey Seams have all been extensively worked and goafed in a vertical line at this Colliery.

The seams at this Colliery rise towards the South and terminate against the bottom of the limestone.

The Manager of this mine, a gentleman of long experience in the district, informs me that he has never met with the sand feeder while working coal at a depth of 30 fathoms below the sand, which he has frequently done both in the whole and brokens.

TRIMDON COLLIERY.

502 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial Deposit			33	0		
Limestone and Marl..			291	6		
Marl Slate			1	6		
Sand			20	10		
To bottom of the feeders			..	..	346	10
Further to the 5/4 seam ..	3	7	59	11	406	9
„ Main Coal ..	5	0	104	0	510	9
„ Low Main..	3	7	143	7	654	4
„ Hutton	2	4	128	5	782	9
„ Harvey ..	3	7	140	8	923	5

The 5/4 Seam is extensively worked at the above Colliery at 60 feet below the feeders as alluded to.

Deaf Hill Colliery, 1892.

518 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			69	2		
Limestone and Marl			270	4		
Marl Slate			4	5		
Sand, not much water			7	5		
To bottom of the feeders					351	4
Further to the 5/4 seam	3	7	133	6	484	10
„ Main Coal	3	10	99	10	584	8
„ Low Main	3	6	130	1	714	9
„ Hutton	2	5	117	4	832	1
„ Harvey	3	1	135	2	967	3

This Colliery is a short distance north of Trimdon Colliery. There was not much water met with in sinking, and the 5/4 seam is extensively worked at 133 feet below the feeders; also the Main Coal, Low Main, and Harvey seams.

Wingate Grange Colliery.

400 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			87	0		
Limestone and Marl			262	0		
Marl Slate			5	6		
Sand			1	2		
To bottom of the feeders					355	8
Further to the 5/4 seam	4	1	91	10	447	6
„ Main Coal	5	0	90	10	538	4
„ Maudlin	—		—		—	
„ Low Main	3	2	124	7	662	11
„ Hutton	2	8	115	1	778	0
„ Harvey	3	8	144	11	922	11

The manager informs me that the 5/4, Main Coal, Low Main, and Harvey seams have all been extensively worked and goafed in a vertical line without bringing down any of

the feeders; further, that the feeders are unequally distributed over the district, but certainly give unequivocal signs of their presence.

The existence of large faults should be regarded with suspicion, as in his experience of the district many of these undoubtedly extend into the Permian, and in a great number of instances are the seat of cavities which communicate along the line of disturbance, and if approached too nearly would cause disaster, while operations a few yards away might pass unharmed.

Many years ago, and before the South-East Coalfield was much explored, while prosecuting the workings in the 5/4 seam to the south of the shaft, they suddenly came upon the outcrop close to the sand and met with a considerable quantity of water. Strong dams were at once put in which effectually kept the water back, and this district and south side workings generally were abandoned.

HUTTON HENRY COLLIERY (North of Marley Pit).

400 feet above Sea Level.

							Depth from Surface.	
					Ft.	In.	Ft.	In.
Surface or Alluvial deposit					190	8		
Limestone and Marl					248	4		
Marl Slate					1	9		
Sand (hard)					14	3		
To bottom of the feeders					..	..	455	0
Further to Low Main—								
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Coal ..	2	6						
Band ..	2	4						
Coal ..	2	2						
			7	0	139	5	594	5
Further to Hutton			3	3	95	8	690	1
,, Harvey, 1in. band, in middle ..			5	3	141	4	831	5
,, Busty, two small bands			3	1	13	11	845	4

PERSEVERANCE PIT (about 500 yards South of Marley Pit).

420 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			128	0		
Limestone and Marl			311	11		
Marl Slate			0	10		
Sand			35	0		
To bottom of the feeders			..	..	475	9
Further to Low Main (denuded) ..			—	..	—	
„ Hutton	3	3 ..	185	0 ..	660	9
„ Harvey, 2in. band, middle	5	7 ..	145	10 ..	806	7
„ Busty, two small bands, 7in. ..	3	9 ..	10	6 ..	817	1
Sunk further			118	8 ..	935	9
Bored further			57	4 ..	993	1

No other workable seam met with.

The upper seams appear to have been denuded down to the Low Main at the Marley pit, and down to the Hutton Seam at the Perseverance pit. The Coal Measures rise to the south, where they crop out or run into the newer rocks a little to the South of the old Hartbushes or South Wingate Shaft, which is 437 feet above sea level. The "Butterknowle Dyke" is known to pass in front of them at Black Hurworth, about 600 yards to the south of this Shaft, but it has not been proved by any of the workings.

In working the Hutton and Harvey seams to the south of the pits the measures appear to have thinned off more rapidly than anticipated, and such large feeders of water, apparently from the limestone and sand, were met with that the Colliery was eventually abandoned.

In comparing the sections of Wingate Grange, about one mile to the N.W., and Castle Eden, about 1½ miles

N.E. from Hutton Henry, it will be seen that all the seams from the 5/4 downward have been met with in the two former sections, whilst at this Colliery (Hutton Henry) nothing was found down to the Low Main at the North, or Marley pit, which would point to some disturbance of the strata between places, probably a split off the "Butterknowle Dyke" taking place in the neighbourhood of Garmondsway Moor old pit and running down the valley as shown on the accompanying plan.

CASTLE EDEN COLLIERY.

320 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			13	6		
Limestone and Marl			619	1		
Marl Slate			0	10		
Sand			12	0		
To bottom of the feeders			—		645	5
Further to the 5/4 seam (only partly worked)	4	4	69	6	714	11
Further to the Main Coal (only partly worked)	5	5	43	0	757	11
Further to the Maudlin	1	8	46	8	804	7
Further to the Low Main (extensively worked)	4	9	106	5	911	0
Further to the Hutton (only partly worked)	3	9	126	9	1,037	9
Further to the Harvey (not worked)	3	0	164	3	1,202	0

This Colliery has been subject to sudden outburts of water while working the Low Main seam to the south of the Royalty approaching the outcrop previously mentioned; the feeders have generally run off in a few months, but the last one met with while removing some pillars in the South or

Halam district, said to be from 1,500 to 2,000 gallons per minute, and being in an unfavourable district for drainage, was, for the want of efficient pumping machinery the means of drowning out the Colliery.

Although extensive goaves have been formed in the Low Main seam, only a short distance north of the above-named outbursts of water, they have not brought down any of the sand feeders into the workings.

The Magnetic line of dip at this Colliery is N. 77 E., and the angle about 1 in 18.

There are also several other large Collieries which have been sunk through and extensively worked in various seams under the Permian, and may be considered as being in the most dangerous part of this water-bearing strata, without having brought down any of the above-mentioned feeders, viz.:—Hetton, Eppleton, Elemore, South Hetton, Shotton, Ludworth, and others.

In addition to the above a number of Collieries have been sunk close to the outcrop or Bassett edge of the limestone, and although many of them may have escaped the feeders in the actual sinking, the workings have been freely extended under the Permian, notably the following:—

Herrington Colliery.—This is a comparatively new winning, worked under the limestone hills of Newbottle and Offerton, and adjoining Silksworth Colliery. There was no limestone met with in sinking the pits. The 5/4 seam was met with at 125 fathoms, Main Coal at 138, Maudlin at 146, Low Main 162, and Hutton seam at 170 from surface.

Pensher Colliery (Whitefield Pit).—Sunk close to the Permian outcrop, but there was no limestone or sand feeder met with in the sinking. This is an old pit, and has been extensively worked in several seams under the limestone. Depth to the 5/4 or first workable seam 80 fathoms, and to the Hutton seam 123 fathoms from the surface.

NEWBOTTLE COLLIERIES.—The Dorothea Pit and the Margaret Pit are both sunk close to the Permian outcrop, but no limestone was met with in the sinkings.

The DOROTHEA PIT is 81 fathoms to the 5/4 seam and 129 fathoms to the Hutton seam. The MARGARET PIT sinking was similar to the Dorothea, and the depth to the 5/4 seam is 69 fathoms, and 115 fathoms to the Hutton seam. They are both old pits, and have been extensively worked under the Permian in all the seams.

The HOUGHTON PIT of the same Collieries is sunk just under the limestone escarpment, but clear of both the limestone and sand feeders, which do not appear in the section. The depth to the 5/4 seam is 82 fathoms, which has only been partially worked; the depth to the Hutton seam is 134 fathoms. The Main Coal, Maudlin, and Low Main seams intervening, have all been very extensively worked and goafed under each other under the limestone without any disturbance of the feeders.

NORTH HETTON (MOORSLEY PIT) is sunk very close to the outcrop; at one side of the pit there was six feet of sand and at the other only two inches, then some loose broken limestone. Depth to the 5/4 seam 34 fathoms, and to the Hutton seam 100 fathoms. All the seams have been worked and goafed under the limestone.

PITTINGTON COLLIERY (LONDONDERRY PIT) was also sunk on the edge of the outcrop, under the Pittington Hills, and on the opposite side of the valley from Littletown; no limestone was met with in the sinking. The depth to the 5/4 seam is 40 fathoms, and to the Hutton seam is 90 fathoms. The workings were chiefly under the Permian, and two or three seams have been goafed.

LITTLETOWN COLLIERY.—In sinking close to the outcrop eight feet of sand was met with, yielding 750 gallons of

water per minute, but no limestone. The depth to the 5/4 seam is 36 fathoms, and to the Hutton seam 94 fathoms. There are two or three seams worked and goafed under the limestone.

SHERBURN HILL COLLIERY.—Also sunk on the edge, but no mention is made in the section of limestone. The depth to the 5/4 seam is 38 fathoms, and to the Hutton seam 89 fathoms, with extensive goaves under the Permian.

CASSOP COLLIERY.—Both the A and B Pits and the Vale Pit are sunk in the Cassop Valley, and close to the limestone outcrop. In sinking the A Pit about six feet of limestone was met with and 18 feet of sand, containing much water, which was tubbed back. The B Pit, which was only 60 yards off, missed the sand altogether. The depth to the 5/4 seam is 57 fathoms, and to the Main Coal 71 fathoms.

The Vale Pit, situated about half a mile west, was sunk close to the cliff or limestone outcrop, but neither limestone nor water were met with, and no tubbing was required. The depth to the 5/4 seam is 35 fathoms, and to the Main Coal 51 fathoms. Coal was worked at both these Collieries on both sides of the valley, and largely under the limestone. and the two seams were extensively goafed above each other.

COXHOE COLLIERIES.—These Collieries are all sunk on the west edge of the Heugh Hall limestone outcrop, and extensively goafed in the 5/4 and Main Coal seams under the Permian at a depth of from 20 to 40 fathoms.

The foregoing completes my notes on what may be termed the Collieries on the north-east coast. The following remarks relate to the Collieries which are (or have been) working under the limestone from the Coxhoe district to the Western outcrop of the Durham Coalfield, viz.:—

THRISLINGTON COLLIERY.

410 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			10	0		
Limestone and Marl			114	0		
Marl Slate, Sand .. } not mentioned in Section.						
To bottom of the feeders			—	..	124	0
Further to the 5/4 seam (denuded)	—	..	—	..	—	
Further to the Old Main Coal Waste..	—	..	55	6 ..	179	6
Further to the Low Main..	2	6 ..	153	6 ..	333	0
" Hutton Seam	1	10 ..	95	5 ..	428	5
" Harvey Seam	4	4 ..	186	9 ..	615	2
Bored to Busty	2	11 ..	137	4 ..	752	6
Bored still further	—	..	187	9 ..	940	3

This Colliery is sunk on the slope of the Limestone Hills, near to the Ferry Hill old blast furnaces, and 26 chains south of the "Butterknowle Dyke."

The workings have hitherto been confined to the Harvey seam which rises rapidly southward to a vertical height of 252 feet above the level of the shaft, then takes a turn in the opposite direction, descending at about the same rate of inclination to the face of the working within 60 yards of their south boundary, and was there found to be about 40 feet below the level of the seam at the shaft, there were found some indications of another rise or roll setting-in in the direction of Bishop Middleham Colliery, hereafter referred to.

A stone drift was driven from near the shaft, about 1,400 yards in length, cutting the Harvey seam on the south side, for the purpose of drainage and more economical haulage

from the far-off districts; this drift cut through the Busty seam at both sides of the roll, showing a section on the north side of

	Ft.	In.	Ft.	In.
Coal	2	11		
Band	6	9		
Coal	1	9		
			11	5

	Ft.	In.	
And on the South side of Coal ..	2	6	Top Section.
Band ..	4	0	
Coal ..	2	0	Bottom Section.
Shale ..	0	6	
Coal ..	1	0	
	10	0	

Exploring drifts have recently been driven for 200 yards in the bottom section on the south end of the drift.

About 500 acres of goaf has already been formed on the crown of the hill in the Harvey seam without bringing down any feeder of water.

Further detail will be found on the enclosed hand sketch.

MAINSFORTH COLLIERY.

275 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			11	0		
Limestone and Marl ..	Heavily watered.		206	4		
Marl Slate			2	5		
Sand (hard, but somewhat softer at bottom)..			3	5		
To bottom of the feeders.. ..			..	..	223	2
Further to the 5/4 Seam ..	4	6 ..	98	6 ..	321	8
Further to the Main Coal, 4ft. 2in. of band at 18in. from top	9	4½..	74	5 ..	396	1

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Further to the Maudlin ..	4	1 ..	76	10 ..	472	11
,, Low Main..	2	0 ..	68	7 ..	541	6
,, Hutton ..	2	1 ..	91	2 ..	632	8
Further to the Harvey, 4in. of band at 18in. from top	5	1 ..	220	10 ..	853	6
Bored to Busty, 4ft. 10in., with 11in. of band in middle of seam			178	0 ..	1,031	6
Bored further to the Brockwell Seam (see following Section)			90	2 ..	1,121	8

Section of the Brockwell Seam, as bored to:—

	Ft.	In.	Ft.	In.
Coal	0	10½		
Soft Shale band	0	1½		
Coal, Splint..	0	3		
Shale with scars of Coal	0	4		
Coal, with thin Shaly partings.. ..	0	9		
Black Shale, some Coal..	0	3		
Coal	0	6		
Coal, Cannel	0	3		
Coal, good	1	3		
Band	0	2		
Coal, good	0	3		
Coal, Coarse, and Shaly partings ..	0	1½		
Shale with scars of Coal..	0	1½		
Coal, with Shale	0	3		
			5	6

This Colliery is also sunk on the south side of the "Butterknowle Dyke," and about a quarter of a mile south of Ferry Hill Station, on the North-Eastern main line of Railway, and near to where the Lower New Red Sandstone is exposed in the railway cutting a little north of the station, called Rudds Hill.

Very great difficulty was experienced in sinking this Colliery in consequence of its being so heavily watered. The

winning was in close proximity to the north end of what is known in this locality as "Morden Carrs," and no doubt much of the trouble and expense was due to the copious percolation of the water through the open fissures of the limestone.

Only one of the shafts was got down to the Harvey seam, and a drift was driven about 200 yards to the south and stopped. The band (see sect.) increased to 6ins. in the face. A drift was also driven about 70 yards north from the shaft, where the band disappeared altogether.

After many months of anxiety, disappointment, and very great expense, the second shaft was abandoned in the limestone, and all operations were suspended, and eventually the place was dismantled.

BISHOP MIDDLEHAM COLLIERY.

300 feet above Sea Level.

	Ft.	Ins.	Depth from Surface. Ft.	Ins.
Surface or Alluvial deposit	30	0		
Limestone and Marl (3,000 gallons of water)..	169	0		
Marl Slate, Sand .. } not mentioned in Section.				
To bottom of the feeders	—	..	199	0
Further to a Seam of Coal marked on Section as Hard and Good, no name, 3ft. 1in...	219	1 ..	418	1
To another Seam ("lately worked,") no name mentioned on Section, 2ft. 9in.	8	2 ..	426	3
Bored further, several thin Seams met with, but none of them workable..	902	9 ..	1,329	0

This Colliery is sunk about two miles south and east of Mainsforth Colliery, being still further to the south of the "Butterknowle Dyke," and was heavily watered in the sinking.

They first commenced exploring southward, and when at about 300 to 400 yards they found from the great inclination of the seam (about 4ins. to the yard rise) they were fast approaching the outcrop at the base of the limestone, and a large quantity of water was met with.

The workings were then turned in a northerly direction at the same steep inclination towards the Thirslington Colliery; the expenses of working and pumping were found to be so heavy that the Colliery had eventually to be abandoned, and was dismantled.

There seems to be little doubt that the two seams mentioned in the above Section are identical with those now worked at Thirslington Colliery.

CHILTON COLLIERY.

300 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			7	4		
Limestone and Marl, heavily watered			53	0		
Marl Slate, not mentioned			—			
Sand, yellow, very soft, heavily watered			69	0		
To bottom of the feeders.. ..			..	..	129	4
Further to the 5/4 seam	4	10	254	3	383	7
Further to the Main Coal, split, 5ft. 6in. band .	4	4	72	10	456	5
Further to the Low Main } Not in Section.						
„ Hutton .. } Not in Section.						
„ Harvey	4	4	476	3	932	8
„ Busty, split up, useless			—	..	—	
„ Brockwell ..	5	2	268	0	1,200	8

This Colliery, sunk on the south side of the "Butterknowle Dyke," is situated between the Mainsforth and Windlestone Collieries, where very great difficulties were experienced in sinking through the limestone and sand feeders.

There were also other large feeders of water met with in the lower strata.

The 5/4 and Main Coal seams were extensively worked and goafed in a vertical line without bringing down any of the upper feeders.

The Harvey seam was not much worked, being very wet and having a soft clay thill.

The Brockwell seam was only proved by the sinking of one of the shafts, and I took the following section on the 27th February, 1883, about 90 yards south-east of shaft, shortly before the abandonment.

	Ft.	In.	Ft.	In.
Coal, bright and soft	0	8		
Band (3 in. at the shaft)..	0	1½		
Coal, coarse and splinty	2	0		
Black danty parting..	0	0¼		
Coal, bright and soft	2	4¾		
			5	2½

WINDLESTONE COLLIERY.

300 feet above Sea Level.

	Ft.	In.	Ft.	In.	Depth from Surface. Ft.	In.
Surface or Alluvial deposit			24	0		
Limestone and Marl			184	8		
Marl Slate / Sand .. } Not mentioned in the Section.						
To bottom of the feeders.. ..			—	..	208	8
Further to the Low Main ..	2	9 ..	104	7 ..	313	3
„ Hutton, 11in. of band	4	7 ..	177	1 ..	490	4
Further to the Harvey, 3in. of band	3	0 ..	41	0 ..	531	4
Further to the Busty.. ..	2	7 ..	102	10 ..	634	2
Further to the Brockwell *(see Section)*	6	4 ..	123	7 ..	757	9
Sunk further (into a ganister bed) ..			323	6 ..	1,081	3
Bored still further	—	..	193	4 ..	1,274	7

At this Colliery, as at Chilton, Mainsforth, and Bishop Middleham, immense feeders of water were met with, and only one of the shafts reached the seams.

This Colliery is also on the south of the "Butterknowle Dyke" and near to the outcrop of the Coalfield.

The upper seams appear to have been denuded down to the Low Main, and at the time of sinking there was a diversity of opinion as to the identity of the seams met with; however there can now be little doubt that the above naming of the seams is correct.

The last stratum sunk through was a bed of ganister, four feet in thickness, and it is quite evident from this that they had got into the Lower Coal Measures where only coal seams of a few inches in thickness were met with.

The boring did not prove the least trace of coal, and the hole was stopped after boring six inches into what is called "Grey Whin," which is in all probability the Millstone Grit. Eventually a pair of drifts were started in the seam at 758 feet from the surface, which proved to be the Brockwell seam and the following is a section taken at the shaft:—

	Ft.	In.	Ft.	In.
Coal, good	1	1		
Black metal band	0	4		
Coal, good..	1	6		
Coal, coarse	0	8		
Seggar clay band	0	5		
Coal, good	0	6		
Seggar clay band	0	6		
Coal, good	1	4		
			6	4

The drifts were driven on a course N. 89 W. from the shaft, a distance of 2,123 yards, terminating under field No. 61, Ordnance Map, near to the Windlestone farm house and 32 chains east of the Hall, and left off in the following section:—

	Ft.	In.	Ft.	In.
Soft black stone on top	0	1		
Coal	0	9½		
Black splinty stone..	0	3		
Coal, good	1	10		
Black stone	0	2		
Coal	2	0½		
			5	2

The drifts dipped towards the west, and were near 600 feet below the shaft bottom when stopped in May, 1884, thus bringing the seam pretty near on a level with the Brockwell Seam at Chilton Colliery (*see preceding Section*). This would indicate that the large wave or roll mentioned in the Thrislington Colliery comes within the range of the two latter Collieries.

The following section of the Brockwell seam of South Durham Colliery is taken on a line with the Windlestone drifts, and 1,320 yards further west, showing how the seam improves westward from Windlestone:—Coal, 3 ft. 4 in.; Band, 3 in.; Coal, 2 ft.

At the Binchester, Westerton, Leasingthorne, Black Boy, Auckland Park, South Durham, Adelaide, and Shildon Lodge Collieries, no limestone or sand was met with in the sinkings, but they are all working more or less under the Magnesian Limestone.

MIDDRIDGE COLLIERY.

400 feet above Sea Level.

	Ft.	In.		Depth from Surface. Ft.	In.
Surface or Alluvial deposit	12	0			
Limestone and Marl..	114	0			
Marl Slate } not mentioned in the Section.					
Sand .. }					
To bottom of the feeders				126	0
Further to the Busty seam; Coal 3ft. 3in., Band 2ft. 2in., Coal 3ft. 3in., 6ft. 6in.	98	4	..	224	4
Further to the Brockwell seam, 5ft. 4in.	153	0	..	377	4

This is the last Colliery sunk on the Permian range, and is close to the south-western outcrop of the Durham Coalfield.

The upper seams are all denuded down to the Busty.

The Brockwell seam is now practically all goafed, and goaf has also been formed in the Busty Seam, immediately above it.

The angle of dip is N. 17 W. towards the South Durham Colliery workings, and about 2½ inches to the yard.

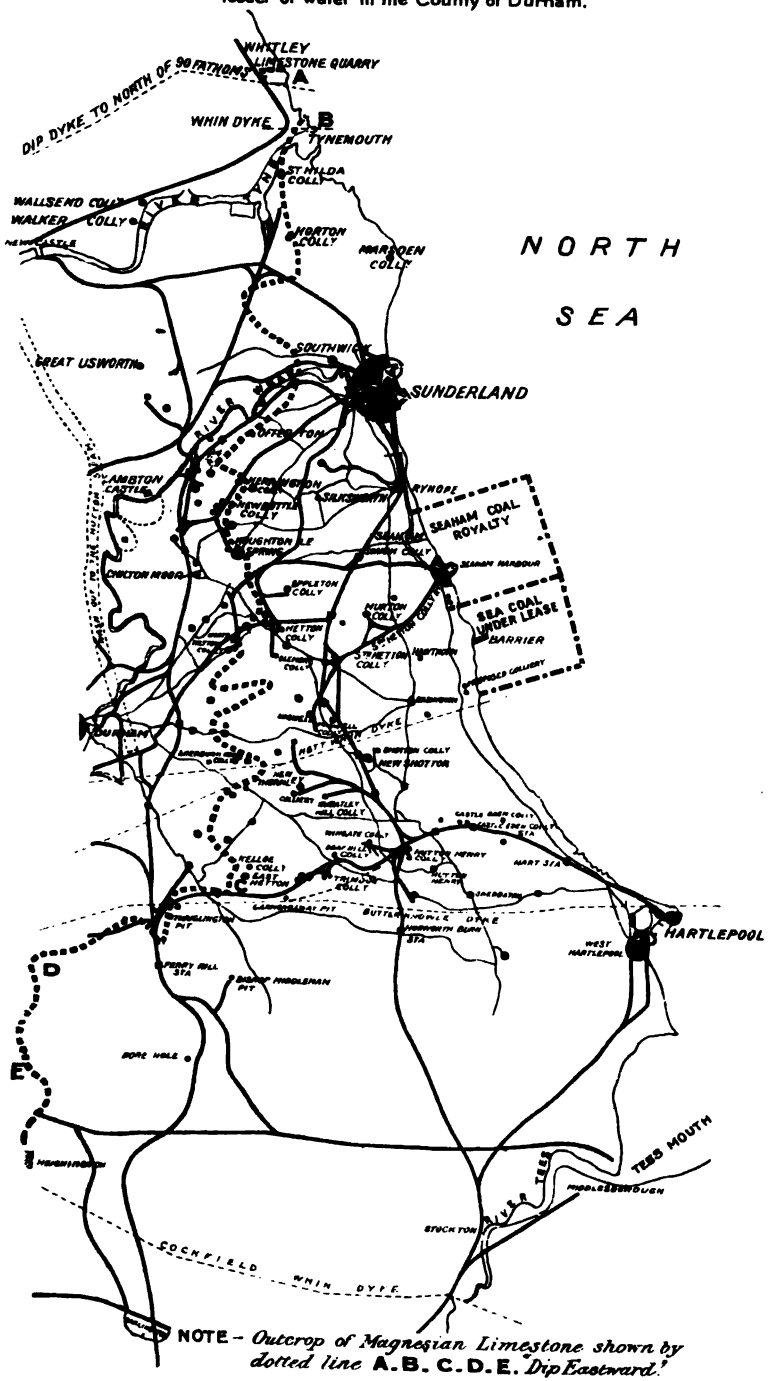
This Colliery has been much troubled with water, but I do not attribute it to the limestone feeders alone; the strata are open and allow the surface water to percolate freely during wet weather.

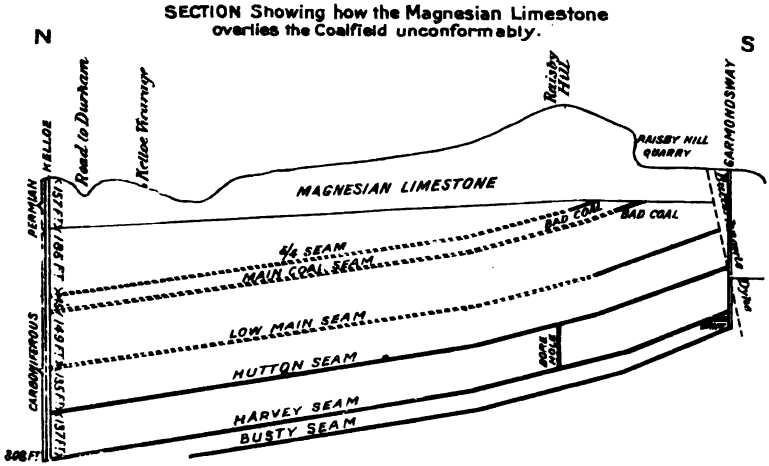
If further proof were needed as to the southern outcrop of the Durham Coalfield, I think it will be found in the following section of a bore hole which was put down by the late Mr. Smith Stobart and his partners, on the west side of the main line of the North Eastern Railway and 1,000 yards south of their Bradbury Station, about eight miles north of Darlington, and close to the edge of Morden Carrs, and about 260 feet above sea level.

	Ft.	In.	Ft.	In.
Surface or Alluvial deposit	163	0		
Limestone and Marl	186	10		
			349	10
Posts, Shales, &c., very hard strata			208	2
Total depth bored			558	0

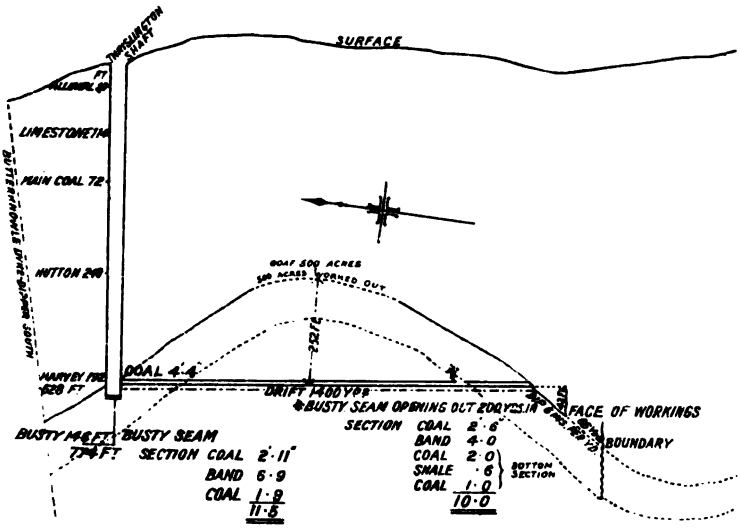
There was no trace of coal in this boring. The rods were broken and lost, and operations discontinued after boring 13 feet into the millstone grit in February, 1874.

PLAN showing the position of the **COLLIERIES** referred to in the paper by **Mr. THOMAS BELL**, on the working of coal mines under sea, also under the Permian feeder of water in the County of Durham.





Section of Seams between
KELLOE and GARMONDSWAY MOOR SHAFTS.



SECTION AT THRISLINGTON COLLIERY
Showing the ROLL or RISE in the HARVEY SEAM.

In conclusion, I would remark that the Windlestone, Chilton, Mainsforth, and Bishop Middleham Collieries, all sunk near to the south outcrop or Bassett edge of the Durham Coalfield, have been most expensive and disappointing

It has been estimated by competent authority that there has been over a million of money spent on these Collieries, which have been totally unproductive and are now all dismantled.

Mr. HALL: I have great pleasure in moving a vote of thanks to the writer of the paper, who I am sorry not to see here. The paper is very interesting from a historical point of view, no doubt, as regards the different Collieries in County Durham; but I expected that we should have had more about the under-sea coal. Mr. Bell seems to have left that out almost entirely. The under-sea coal, as distinct from the coal under the Permian feeders, is the more interesting of the two. However, when Mr. Bell is here he will perhaps tell us more about it.

Mr. STIRRUP seconded the vote of thanks, which was passed unanimously.

The CHAIRMAN said their thanks were due also to Mr. Dickinson for reading the paper in Mr. Bell's absence. It seemed to him a very valuable paper for the Society to have. As to the postponement of discussion, he invited an expression of opinion from the members.

Mr. STIRRUP said he thought it would be in accordance with the feeling of the members that discussion should be postponed until the paper was in print. The under-sea coal had many points of interest. It could not be mined without much risk, and there was the further question—which he

had never been able to understand—to whom was the royalty payable for the getting of that coal? Did it belong to the Government or to some private owner?

Mr. DICKINSON: There is no question that, beyond a certain limit, the under-sea coal belongs to the Crown.

The meeting having decided that the discussion should be postponed,

Professor BOYD DAWKINS said: I should like to have the satisfaction of answering Mr. Stirrup on the question of ownership. Between high-water mark and low-water mark belongs to the owner of the manor; but immediately you get to low water, right away out for three miles, the ownership is vested in the Crown. That has been settled by the Courts in a leading case.

Mr. HALL: And beyond three miles?

Professor BOYD DAWKINS: It is no man's property beyond the three miles; you are then on the high seas. It is for anyone who can get at it.

Mr. HALL: And they can get at it by paying a way-leave.

Professor BOYD DAWKINS: Arrangements are made by the Crown with people who are sometimes able to get at the coal under the sea. At Dover they have specially limited their operations to a distance of a mile and a half from low water, in order to prevent them making a tunnel under the sea and right away to France.

REPORT OF THE DELEGATE TO THE MEETING OF THE BRITISH ASSOCIATION AT DOVER, SEPTEMBER, 1899.

By Mr. Mark Stirrup, F.G.S.

The British Association Meeting at Dover in September last, to which I had the honour of being delegated, besides its usual features, had a special one super-added of an international character.

The meeting of the French Association for the Advancement of Science having been appointed to take place at Boulogne-sur-Mer, Dover was selected for the British meeting, as the most convenient place for an inter-change of courtesies between British leaders of Science and those of French and other nationalities. Some apprehension was felt, owing to recent events in France, that difficulties might arise in carrying out the programme of reciprocal hospitalities, but the hearty welcome and enthusiasm displayed on both sides of the Channel at the respective receptions, soon made evident that the device which proclaims that "La Science n'a pas de patrie" (Science knows no distinction of country), is no mere empty symbol.

To serve this laudable purpose of international exchange of good-will, Dover was fixed upon, though it is a town of smaller size and importance than those usually chosen for these annual gatherings. From this cause, some slight disadvantages were soon manifest; firstly, in the difficulties experienced in obtaining lodging accommodation, at a time when the town was filled with its usual summer visitors; and secondly, the absence of a local daily newspaper, a deficiency, however, largely made good by the *Times* and other London papers. The disadvantage in the latter case, was experienced by those ardent and omnivorous members who seek in the columns of the local press for

an account of the papers read and discussions thereon in all the various section-rooms of the Association, in this way, attempting to repair in some degree, that human disability which pursues the votary of science, as well as the ordinary mortal, when he tries to be in two or three different places at the same time.

These little troubles were however soon forgotten in the warmth of the welcome and the hospitality extended to the visitors by the Mayor, Mayoress, and Corporation of Dover, as well as by the local committee of the neighbouring gentry. It is beyond my province to discuss the joyous and friendly character of the international civilities, the fraternal speeches of good-will that signalized the banquets at Dover, Canterbury, and Boulogne-sur-Mer, which however demonstrated once again that the field of science was a peaceful battleground of friendly rivalry in the extension of the empire of knowledge.

With these few general remarks, I must now turn to the special object of my report, which is, to render an account of the meetings of the delegates of the Corresponding Societies of the Association.

Thirty-six societies were represented by delegates at Dover, that being a rather smaller number than usual; of these rather more than half were Natural History Societies or Field Clubs, while the others represented Archæology, Geography, Geology, Mining, &c., &c.

As usual two meetings of the delegates took place, the proceedings of which, the delegates are asked to report to their respective societies, a direction which I now proceed to fulfil.

At the first meeting on Thursday, September 14th, the Chairman, the Rev. T. R. R. Stebbing announced that the Admiralty had received favourably the resolution with regard to Coast Erosion passed at the Bristol Conference of

Delegates last year, which sought the co-operation of the Coast Guard Service in recording the changes observable or now going on along the British coasts.

The Chairman then delivered an excellent address on "The Living Subterranean Fauna of Great Britain and Ireland," in which he sought to enlist the aid of Natural History Societies in extending this field of research, which, he said, though small and obscure, was one which had not been overworked or exhausted and promised many discoveries to the diligent searcher.

This field of exploration was near at hand in any underground well or dark cavern, or in the deep recesses of disused coal mines, where hidden from the light of day, spiders, beetles, and other low forms of animals passed their existence, while in the waters small crustaceans, fresh-water shrimps, and other organisms were to be found, all alike presenting features of interest or structural changes due to absence of light and their abnormal habitat. I need not, however, further summarise the substance of the address, seeing that it is printed in the Corresponding Societies' Committee's Report, a copy of which now lies on the table.

At the second meeting of the Conference, on Tuesday, 19th September, an informal discussion took place as to the necessity of some improvement in the management of the delegates' meetings whereby personal intercourse among the delegates might be promoted, giving occasion for interchange of ideas, for which purpose the ordinary meetings with their definite programme gave no opportunity. Disappointment was also expressed that the meetings disclosed little of any special work being done, or any combined effort on the part of the respective societies in the furtherance of scientific investigation. Numerous suggestions were offered as a means of correcting those defects or deficiencies, and after a rather protracted discussion, the whole matter stands over for further consideration at the Bradford meeting.

The Chairman, Professor W. W. Watts, now called upon Mr. Hugh Blakiston, the Secretary of the "National Trust for Places of Historic Interest or Natural Beauty," to read his promised paper, explaining the aims and work of the Trust.

The National Trust, Mr. Blakiston remarked, was founded in the year 1894 by the Duke of Westminster, the Earl of Carlisle, Lord Hobhouse, and others, and was incorporated as a Limited Liability Company, "to promote the permanent preservation, for the benefit of the nation, of lands and tenements of beauty or historic interest; and for this purpose to accept, from private owners of property, gifts of places of interest and beauty, and to hold the lands, houses, and other property thus acquired, in trust for the use and enjoyment of the nation."

Mr. Blakiston then gave a succinct account of the work already accomplished, but feared their aims and objects were not so widely known as was desirable.

He recommended the creation of local committees to watch over the ancient monuments of each county or district and the formation of a central fund, which fund could be used for the purchase, or to make grants in aid towards the purchase, of properties of national interest, thus preserving them from neglect or injury.

Mr. Blakiston recommended the Trust to the consideration of the Societies represented, and appealed to their members for support.

A vote of thanks being accorded to Mr. Blakiston, the Chairman, Professor W. W. Watts, called upon the representatives of the Sectional Committees that were present to make any remarks or suggestions that they were wishful to bring before the delegates.

The Chairman, representing Section C (Geology), acknowledged the assistance of local societies to the committees

engaged on two investigations, viz.:—that of the Erratic Blocks of the British Isles, and that for the securing of Photographs of Geological Interest. With regard to the latter, he said that the Committee hoped to be able to undertake the publication of typical geological photographs in such a way as to render them easily obtainable, and that it would greatly help the Committee if local societies would agree to purchase a series of these photographs.

The representative of Section D recommended the study of the fauna of wells and caverns to the attention of the Corresponding Societies.

Mr. Wager, representing Section K, mentioned the appointment of a committee to consider the geographical distribution of mosses.

With these announcements the meeting of the Conference was brought to a close.

I will now, by your permission, notice briefly some few of the communications made to the Section of Geology. (Section C.)

The first that claims attention is the address of the President of the Section, Sir Archibald Geikie. This address is an impartial and clear statement of the antagonistic views of the physicists and the geologists as to the age of the earth, a controversy which has of recent years excited much attention owing to the rank and scientific attainments of the disputants. Sir Archibald Geikie, in his masterly defence of the geological position, mentions the remarkable fact of the persistent disregard by Lord Kelvin "of the strong body of evidence adduced by geologists and palæontologists in favour of a much longer antiquity than he is disposed to allow for the age of the earth."*

As this discourse has been published in the current scientific periodicals, I need only thus draw attention to its

* Geo. Mag., Oct. 1899.

importance as an explicit statement of the argument from its geological aspect.

Among the subjects of local as well as general interest brought before the Section, the first perhaps in importance were those having reference to the coal exploration now going on in the vicinity of Dover.

Mr. R. Etheridge, F.R.S., traced the relations between the Dover and Franco-Belgian Coal Basins, showing, by aid of some large diagrams, that the Dover Coalfield was an undoubted extension to England of that already exploited in the Franco-Belgian area. Moreover, he expressed in very confident terms his belief in the ultimate success of the work now going on near Dover.

Professor W. Boyd Dawkins followed in a paper on a kindred topic, entitled the South-Eastern Coalfield, in which he spoke more particularly of the various borings now or recently in operation in Kent, with the object of ascertaining the range of the hidden Coal Measures in the South-Eastern district.

These borings, some half-dozen or so in number, are all the work of private enterprise, and so far, one only, that at Ropersole, eight miles to the north of Dover, has reached the Coal Measures at a depth of about 1,700 feet. These measures the Professor believes to be a portion of the same series as those at Dover. With regard to the other borings, some of them have not been carried deep enough to yield any evidence.

Another important paper having reference to the extension of our British coal resources, was that of Mr. Walcot Gibson, F.G.S., on "Some recent work among the Upper Carboniferous Rocks of North Staffordshire, and its bearing on concealed Coalfields."

The author said that he had met with workable seams of coal at reasonable depths beneath the Red Rocks surrounding

the South Staffordshire Coalfield, but there remained large areas lying between the known coalfields of Shropshire, North Staffordshire, and Notts. that had not at present been explored.

Within the South Staffordshire area there were considerable tracts of so-called Permian rocks which recent investigations had proved to be conformable to the Upper Coal Measures and to contain a carboniferous flora. Further, he stated, there seems to be little doubt that the Coal Measures of the Pottery Coalfield lay not far from the surface under Little Madeley and Craddock's Moss.

Mr. Gibson's conclusion was that a thorough and complete examination of the explored Coalfields of the Midland Counties and of the bordering New Red rocks would be of the highest importance in determining at what depth the productive measures lie beneath the great central tracts of the Midland Counties.

To those of our members taking an interest in questions of theoretical geology, I might point their attention to a short and interesting address by Professor Sollas on "Homotaxy and Contemporaneity," wherein he gave strong reasons for dissenting from the doctrine so strongly enunciated by the late Professor Huxley in 1870—that identical fossils from two different localities, widely separated, did not prove the deposits contemporaneous.

Professor Sollas said the distribution of zonal fossils had unexpectedly vindicated the old-fashioned notion of the contemporaneous formation of similar stratified systems over great parts of the world and that no one could any longer assert that "a Devonian fauna and flora in the British Islands may have been contemporaneous with Silurian life in North America." Professor Sollas's argument rested on the time required for a species to migrate from one place to another *versus* the time required for the evolution of species.

The lapse of time, remarked the lecturer, during migration or transport was a vanishing quantity in comparison with the long periods occupied in the evolution of species, thus he said, recent work has been such as to inspire geologists with confidence in the logical basis of their methods.

Mr. Percy F. Kendall of the Yorkshire College reported that a committee of the Yorkshire Geological and Polytechnic Society had this year been engaged on an examination of the underground waters of Craven in order to trace the source of the river Aire. For this purpose various chemical experiments have been made, particulars of which will be found in the pamphlet on the table, issued by the Committee.

In choosing the foregoing papers and reports for mention, from among others of equal interest in their several departments, which were presented to Section C, it will be understood that as some selection was necessary in order to confine this report within due limits, the personal predilections of your reporter are in some measure accountable for the choice.

In conclusion, I may add, that the usual reports from the several committees engaged on scientific investigations connected with geology were presented to the section.

Moreover, since the close of the Dover meeting, a list of the committees appointed for continuing these researches has been received by the Society with the request that it should be impressed upon the Society and its members individually, the importance of taking part in the work of as many of the committees mentioned in the list as may be found practicable in our districts.

This list now lies upon the table for your perusal.

Professor Boyd Dawkins conveyed the thanks of the meeting to Mr. Stirrup for his interesting communication. They were, he said, indebted to Mr. Stirrup for representing the Society so well at the British Association meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIV. VOL. XXVI. SESSION 1899-1900.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, January 12th, 1900, in the Mining School, Wigan.

Mr. JOHN GERRARD (in the absence of the President) in the Chair.

NEW MEMBER.

Mr. ADAM DEAN, Manager, Stopes Colliery, Little Lever, near Bolton, was balloted for and elected a Member of the Society.

Mr. JOSEPH CRANKSHAW, F.G.S., read the following paper on "Coal Mining in South Russia":—

COAL MINING IN SOUTH RUSSIA.

By Mr. Joseph Crankshaw, F.G.S.

It is not the intention of the writer of this paper to attempt an exhaustive or scientific treatise on the above subject, but just to give from memory and in a conversational manner the first impressions of a Lancashire man during a two months' visit to the East, in a district not frequented by tourists, and to a country that I believe is greatly misunderstood by the average Englishman. Russia! —the name at once conjures up visions of eternal snow, of weird dense forests of interminable pines, of wolves howling round the house in huge fierce packs, of secret-police ready to catch an unwary word and hurry the speaker in chains to a living death in Siberia, of a thousand and one things that make one's friends shake their heads and say, with a pitying kind of smile, "Well, good-bye, I wish you a safe return."

I went to Russia feeling all this, and I have returned with pleasant recollections of kindness and hospitality shown to an unknown Englishman without any credentials, and with nothing to recommend him but his nationality and his ignorance!

Many years ago I had the offer of an appointment as Manager to a Coal Company at Heraclea, in Asia Minor. I have felt an interest in the district ever since, and when it became necessary, at the beginning of the year, to take a holiday, I decided to go to Constantinople by sea and then have a look at the place I should have gone to. Consequently I took a passage in one of Wilson's boats

sailing from Hull to Constantinople and Odessa, and sailed in the S.S. "Douro" on the 18th February.

The ship had to stay for a week in Constantinople to discharge cargo, so I thought that this would give me ample time to visit Heraclea and then proceed with the ship to Odessa. I found when we arrived there that I had made two mistakes,—first, in judging distances from a small map, on which Heraclea looks about as far from Constantinople as New Brighton is from Liverpool: and second, I had not calculated that I was going to a country where "to-morrow" is better than to-day, and next-week-but-one better than either!

After leaving the "Douro" at Odessa I took a small coasting steamer to Nikolaiev, the centre for the Black Sea Fleet and the best route to Ekaterinoslav from Odessa, and obtained an introduction to Mr. Woodhouse, the British Vice-Consul at Nikolaiev. I found Mr. Woodhouse an enthusiast in mining, and from him I gained much valuable information. I also found that Ekaterinoslav was a day's journey from Nikolaiev, and that the Donetz Colliery district was another day's journey by train from Ekaterinoslav.

As I was expecting important letters at Odessa I decided first to return there, and then decide upon the journey to Donetz Coalfields afterwards. On my return to Odessa I was introduced to Mr. Smales, shipping agent and coal merchant, and Mr. Webster, ship owner and colliery proprietor.

Mr. Webster gave me an introduction to his partner at the colliery, so I returned to Nikolaiev.

In the meantime, Mr. Woodhouse, the British Consul, had made all the necessary enquiries and arranged for me to be met by Mr. Basphaloff (sales-agent for Messrs. Webster, Kavelenks and Uspensky), who was thoroughly conversant with all the collieries in the Jusowo district.

Jusowo is the name of a town founded by an Englishman named Hughes, and where he has developed large ironworks and colleries which I understand are now valued at over eight millions sterling.

If you look at a map of Russia you will find Mariopol, a port on the north of the Sea of Azov. From it, running north again, is the railway, and just before it joins the line running east and west you will find the town of Jusowo, which is the centre of the bituminous coal district of the Donetz Basin. To the east of Jusowo lie the Anthracite colleries, but these I had not time to visit.

The whole of the Jusowo district is overlaid by an alluvial deposit of gravel and sand, in thickness from 40 to 120 feet, beneath which the coal seams outcrop, so the position of the seams on each estate has to be determined by boreholes, which add considerably to the first cost of developing a new estate. At one colliery that I visited they had put down no less than thirty boreholes. The seams are at a high inclination nearest the surface, being at an angle of 18°, but they get much flatter to the deep, and at about 400 yards they are in some places only from 4° to 6°. Few of the pits are more than 200 yards deep, and rectangular in shape, and about 13 ft. 6 in. × 5 ft., lined with timber, with one or two partitions. The conductors are of wood, and most of the cages are provided with safety catches, called parachutes.

The men, however, generally ascend and descend by "ladders." The winding engines are mostly of the type used in England for underground haulage,—standing on a self-contained engine bed with the drum working on a second motion shaft, and geared about three to one.

These are used at pits with an output of from 200 to 1000 tons per week.

Messrs. Hughes, the New Russia Company, are winding 1000 tons a day from one of their pits, but they have a pair of engines, made by Messrs. Walker, of Wigan, with 42in. cylinder × 7ft. stroke. The manager for Messrs. Hughes is Mr. Williams, a Welshman, and his assistant is Mr. Horsefield, at one time at Clifton and Kearsley Collieries, and probably well known to many of our members.

The workable seams in this district vary in thickness from 72in. to 15in. but the average is about 24in., as many of the seams have an average thickness of from 21 inches to 22 inches only. The coal—as will be seen from the specimens on the table—is generally of good appearance, light in weight, with a fibrous fracture, and is described as a fatty coal. Some of the coals yield a high percentage of gas, but they are also rather high in sulphur, ranging from 0·77 the lowest, to 2·50 per cent.

The system of working is generally pillar and stall, and, as even in the thinnest seams tubs holding from ten cwts. to a ton are used, the main levels are driven about six feet high and six feet wide, and the coal is sent down in sledges which come down the places by gravity and are dragged up again by the old-fashioned chain and belt. The sledges are emptied at the bottom of the places and the coal is refilled into the pit tubs.

Of course the coal being of so soft a nature, the large amount of strait work, and the two or three times handling, causes a large proportion of slack, but this does not seem to be of much importance as they get the same price for the coal independent of size.

There are good shale roofs over most of the seams, so they do not use a great amount of timber. The warrant of several of the seams is a fire-clay of excellent quality, from which every colliery might at least make bricks for use on

the premises. There is very little dirt sent to the surface as the roofing down in the levels is packed in dirt holes driven seven or eight yards deep on the lower side. The only place at which I saw any system of underground haulage was at the Central Pit of Messrs. Hughes, where they have an output of 1000 tons a day.

Most of the pits in the district are working quite a small area, the average being probably under 200 acres. As the land has been the property of peasant proprietors allotted to them at the emancipation of the serfs, it is generally difficult to reconcile the different interests, and, as the coal is good right up to the outcrop, it pays to put down these shallow pits with a small plant for quite a limited area The cost of getting and carting the coal is from 3¾ to 4½ copecs a pood put in railway trucks. The copec is equal to a farthing and there are 62 poods to a ton English. So the cost is from 58½d. to 59¾d. per ton, and, as most of the owners have to cart their coal for several miles to the railway, it cannot be considered excessive.

There is an import duty of 8s. per ton on every ton of foreign coal sent into the country.

The selling price of coal was from 6¼ to 9 copecs a pood, or, from 8s. 1d. to 11s. 8d. per ton, and has gone up considerably since.

The average profit I was informed was quite three copecs a pood, or about 4s. per ton.

One Colliery Manager that I met was dissatisfied because the whole of the output had been sold at 6¼ copecs a pood, although he admitted that it cost them less than 4 copecs per pood after everything had been paid. A proprietor of a small colliery, with a capital of under £40,000, admitted that he was making a profit of £14,000 a year.

The question is:—Will this profit continue?

I had the good fortune to have a conversation with Mr. Hughes himself, the Millionaire Manager of the works. He is a keen, shrewd, business man; thoroughly up to date and taking an active interest in every detail of the works. On the morning I called, he was personally superintending the engagement of batches of fresh workmen.

I discussed the matter with him, and he seemed to think profits would come down, although he admitted that he had been expecting a fall in prices for some time while they had steadily improved.

Other colliery proprietors said: "Yes, the profits will continue, and will increase. The demand will continue to be greater than the supply. Manufactories are springing up in every direction. We have discovered enormous deposits of splendid iron ore at Krivoirog. We have an enlightened and patriotic government, straining every nerve to develop the resources of the country; all that we need is more capital, and for this we can afford to pay a good price."

At the present moment every encouragement is being given to Englishmen and English capital, so I took especial pains to enquire into the security of tenure, and found that foreigners could hold coal lands in Russia just as legally as the Russians themselves, but there is considerable difficulty in arranging terms—especially at the present time.

A good deal of the land is held by peasant proprietors—especially in the Don Cossack Government.

These peasants are generally in the hands of a Jew, whose constant study it is how he can make the last copec out of both buyer and seller. The usual practice is for each party to appoint a Jew, and let the two fight it out. When at last an understanding is arrived at, they each take great credit for their shrewdness. In the meantime, months, and sometimes years, elapse.

Does it not seem a pity that when the land was granted to the peasants the Government did not reserve the minerals to itself? Then there would have been no conflicting interests to reconcile. Mineral leases could have been granted quickly and arranged systematically. The royalties would have brought in a considerable revenue to the Government, and yet there would have been no injustice to the peasant—who is an agriculturalist purely and simply.

The other serious difficulty in Russian coal mining is the labour question.

The Russian peasant is a quiet, industrious and uncomplaining individual while at work, but he cannot be induced to work more than 260 days in the year. He hates the fixed regular hours and restraint of the mines, and at seed-time and harvest great numbers of the peasants depart, either to their own or their parents' farms, to till the ground and gather in the crops. Thus it very often happens that they do not attempt to settle down and make their homes at the mines, but are satisfied with wretched hovels half dug out of the ground. With the great development of the country the demand for labour has, of course, increased, and so the difficulty has become more acute, and in order to induce the men to settle down some of the colliery proprietors—notably those under Belgian control—are building on their estates decent miners' cottages, with a piece of land attached.

There is no form of Trades Unionism in the country and wages in the past have been very low, but they are going up, and as the demand for labour of this kind will probably exceed the supply for some time to come they are bound to go up still more.

The Truck System is also in vogue—especially at the smaller outlying collieries—with the usual result, I presume,

that at the end of the month the poor miner often finds his bill at the shop much bigger than he anticipated.

In conclusion, my impressions of South Russia are that it is a country with an enormous future. I hold no brief for the Russian Government, or anyone else, and I have not a penny at stake there; therefore my only reason for reading this paper is the hope of giving a little interesting information to the Members, and to fill up one of the Meetings, about which our Secretaries are sometimes so anxious. As I travelled over the millions of acres of beautiful rolling prairie—beautiful not from its picturesqueness, but because of its possibilities—offering, as it does, no engineering difficulties in the way of building railways, roads and cities, with a climate more temperate than Canada, a soil that, as Mark Twain expresses it, only needs "Tickling with a hoe to laugh with a harvest," where when English forest and fruit trees are planted they flourish luxuriantly, and where bread stuffs yield magnificently—adding to this its mineral wealth of coal and iron—I felt that it needed no prophetic instinct to believe that in fifty years from to-day the country will have developed enormously, and the population more than quadrupled itself.

Mr. BURROWS proposed a vote of thanks to Mr. Crankshaw for his paper. He had travelled a little and had always thought that the more they prepared themselves in the language and customs the better it would be, but apparently it was not always so. Mr. Crankshaw might tell them how the coal in Russia was disposed of. Was it shipped on the Black Sea, or sent by rail?

Mr. SAINT seconded the motion, which was passed unanimously.

The CHAIRMAN asked Mr. Crankshaw in what geological formation the coal in Russia was found.

Mr. JAMES KEEN asked if the duty had been taken off coal in the Black Sea during the last few months.

Mr. R. WINSTANLEY asked how the men at the collieries were paid, whether by day wage, or tonnage, or how?

Mr. CRANKSHAW said he was exceedingly obliged to them for their vote of thanks. Russia was a country in which he had an intense interest. He went there without knowing anything about it. They had an impression that the Government of the country was exceedingly despotic and that people had to be careful, but he had spoken to Englishmen who had been in the country 40 years and they said they had absolute freedom. When a man went to that country first and had a knowledge of the language and customs of the country they felt his visit had a political interest. The fact that he (Mr. Crankshaw) did not know the language or the customs of the country made people more attentive to him. Replying to the questions, Mr. Crankshaw said, as a matter of fact they did not ship any coal in Russia—they imported large quantities. As to the duty being taken off, at the time he was in Russia there was a very strong feeling that the Government ought to take the duty off coal, as the Railway Companies themselves could not get sufficient coal from the local mines. With regard to the age of the coal measures, they belonged to the Lower Coal Measures. The men were paid, as a rule, by day wage, but in some cases they were paid by piece; it was a matter of arrangement between the employers and employed. The cotton mills were in the north-west of Russia. South Russia had been very little developed up to now, and there the industries were chiefly coal and iron. There were very few textile industries. Russia was undoubtedly an exceedingly good place in which to invest

capital at the present time. All the mills and manufactories he had heard of were doing well, except those under French control.

Mr. CRANKSHAW exhibited and described a number of mineral specimens, including Coal, Iron Ore, China, Clay, &c., which he had obtained during his visit to Russia.

The CHAIRMAN said they were all indebted to Mr. Crankshaw for the valuable paper.

The CHAIRMAN: Our President has sent a telegram, saying that, owing to the death of his brother yesterday, it is impossible for him to be with us. I am sure all deeply sympathise with Mr. Barrett, and regret the cause of his absence.

RESUMED DISCUSSION ON THE SINKING OF TWO SHAFTS AT MAYPOLE COLLIERY, ABRAM, NEAR WIGAN.*

By Mr. James Keen.

Mr. Keen said that since reading his paper they had sunk 200 yards in No. 1 Pit, and the sinking had been completed to a depth of 630 yards, which was 20 yards deeper than No. 2 Pit. The strata passed through was very similar to what they passed through in No. 2 Pit, with a dip of some seven or eight yards between the two pits. The seams of coal were mostly of the same thickness as found in No. 2 Pit; the cannel seam was the same thickness. They had driven out in the cannel, in a north-easterly direction, some 300 yards, and it was seven feet thick at the face, with one foot six of top coal. They had driven in an easterly direction some 80 yards, and the cannel was about the same thickness there, and altogether in the various workings the cannel remained pretty much as they found it, except that it was thickening going in a north-easterly direction. At the present time the output was about 500 tons a week. We are now busy making a pump-house between the two pits. We proposed to put in two pumps, each acting independently, so that any failure in one would leave the other ready to work. Each pump will raise 80,000 gallons an hour, and will have an independent rising main and steam connection. The water we have at the present time is about 60,000 gallons per hour, so that there will be an ample margin of power. Where they had two independent pumps, one always being ready to start if the other failed, they did not require much lodge room, because it would be a very serious

* Part IV., Vol. XXVI., Man. Geol. Soc. Trans.

accident that would cause two pumps to be broken down at the same time. He had seen the Reidler pump working under a heavy load in South Wales, and was pleased with it, but the thought struck him that if the fly-wheel or the shaft or any other part of the pump gave way there was no help for it. They had other pumps ready to start in case of accident. I think for very deep lifts, similar to what I saw in South Wales, the Reidler pump is all right. The pump was pumping with a head of water of 530 yards and appeared to work very well, and, no doubt, economically. At Maypole Pits they were putting in two pumps made by Pearns, and they were the most satisfactory pump without a fly-wheel that he had seen. It was called the Horizontal Duplex Pump. The only difficulty they had was that sometimes they gave a rather short stroke. They could not always rely on it as in the fly-wheel pump, but except for that they were very reliable and useful pumps. He was glad to say the other work was going on satisfactorily.

The CHAIRMAN: We are all very pleased that Mr. KEEN has again come forward to give us further information with regard to his important pumping and sinking operations.

Mr. KEEN said he was rather anxious to know how the sinking they had done corresponded in cost and time with the sinking where they had guide ropes and a loose scaffold. He meant a hanging scaffold where they could go on bricking while the sinkers were working underneath. That was a plan adopted very largely in Yorkshire and South Wales, and he should like to know how it compared with his own. He thought it was cheaper, quicker, and safer to sink without guides and the top scaffold.

Mr. BURROWS did not think it necessary always to have a scaffold to sink with guides. They sunk a pit in which they

put bearers across the pit in the first instance; they put guides down and screwed them to the bearers; they had a carrier which fitted on the two guides; when it came down to the bearers it was left on the indiarubber buffers and the hoppit went on without anything; as soon as it got up to the guides and picked up the carrier it could be wound just as fast as a cage in an ordinary pit.

Mr. SAINT: Mr. Keen says in his paper (page 136, Part IV., Vol. XXVI.): "In no case should there be any backing to the brickwork, my experience being that such constructions always lead to trouble by the brickwork giving way; and above all, have good hard-burnt bricks." I should like to ask Mr. Keen, whom we all know is a practical man, whether he would have any objection to concrete backing.

Mr. KEEN: The probability is that the brickwork and the concrete would part, but there is not that probability where the brickwork is not backed.

Mr. SAINT: Do you think the cavities in the pit sides could be filled up with bricks so well as with concrete.

Mr. KEEN: Oh, yes, I think it could be done quite as well. I think the brickwork makes a better job, and it is certainly quite as cheap as making concrete and putting it in.

Mr. ROBINSON wished to know how the skeleton timbering was done, as he understood Mr. Keen to say it was cheaper than open sinking.

Mr. KEEN: We start off on the last bricking ring, and leave holes in the brickwork for the hangers. When we have sunk down ten feet we put in a length of timbering. The hangers are made of iron, six feet long and about an inch and quarter square, and are turned to hook on the rings. The rings are made of iron segments, 3½ in. by ⅞ in. These

are dropped in the hangers and screwed together at the ends with bolts and nuts; thus we have a complete iron ring hanging from the bricking ring. The rough timber lining consists of boards about 7 in. by 1½ in., and is put in behind, wedged tight as the work proceeds After going down another ten feet, put on a set of hangers and another ring, another length of boards, and wedge them, and so the work goes on until a suitable foundation for brickwork is reached. We have sunk 35 yards at a time without bricking.

Mr. UNSWORTH: Each length of brickwork depends upon itself?

Mr. KEEN: Quite. It has nothing to do with the one above.

Mr. UNSWORTH: It is an improved system on plugging.

Mr. KEEN: We did not lay a single ring on plugs. If you are sinking through water, it would be impossible to have a dry pit if you could not put your rings on the solid. In no instance has the water passed any of our rings, and the pits were always perfectly dry overhead. We made the beds as level as we could and laid the rings on oakum, put cement into it, and built three or four courses of cement brickwork on the cement; the water could not pass through. There is a difficulty when using oakum, for it gets into the pumps, but it would be utterly impossible to lay a ring water-tight under any other circumstances. Where you have 60,000 gallons of water per hour, you must have some soft body to stop the water and cement going through.

Mr. ROBINSON: What length of time do you think is taken up by this timbering?

Mr. KEEN: At snap time most of the sinkers would go out and leave three or four men down and they would send the rings out in half an hour. The great thing is not to go

too far. You want to take it out where the men can handle it easily.

Mr. ROBINSON: About four or five feet.

Mr. KEEN: Yes. When you get deep enough about three men will put a ring in in about an hour and a half. We generally used to get the hangers and rings put in ready, and the timber was placed in position soon after the shots were fired.

Mr. ROBINSON: Had you not any difficulty in taking the timber out?

Mr. KEEN: None whatever.

Mr. MCGEEVER: We had 70 yards of very hard white rock; it could not be chipped with picks. How would you do to get this two feet chipped out, to put a ring upon a bed two feet wide?

Mr. KEEN: We never found any difficulty of that kind. So far as our white rock is concerned, it is quite easy to cut out.

Mr. UNSWORTH moved a vote of thanks to Mr. Keen for the very able supplementary notes he had given them. It was very good of Mr. Keen to come there and give them the benefit of his experiences at Maypole Colliery. Those experiences had been of a very difficult kind. The fact that Mr. Keen had been so good as to give them in detail the benefit of what he had gone through could not be otherwise than of great assistance to those who would have to do similar work in the future. He should like to ask Mr. Keen one or two questions about the engines that he was going to put down. Were the new pumps to be fixed at the level whence the water was now being pumped? He told them he was going to put down a condenser. Where was he going to place it? He said each pump would be equal to raising

80,000 gallons of water an hour, but he did not tell them the speed. If he would tell them the speed it might be of assistance to some of them at some future time.

Mr. KEEN: At the present time we have one pump of the same type at the feeder, and it is pumping 40,000 gallons an hour. That water is dammed up by one of those sealing rings shown in the diagram given in the original paper, and it is let out through valves into a tank, and pumped to the surface from the tank. At the present time we have a pump at 154 yards in No. 1 pit, which is pumping 20,000 gallons an hour up to the big pump, which is going at three strokes per minute. The engine I am going to put in will be 25 yards below the feeder; there is about 15 yards of hard rock, and I do not anticipate any trouble in making the engine house in it. It is an experiment certainly, but there is no pressure on us, and I am not anticipating we shall liberate any water in the roof, because of the thickness of the rock we have between us and the water. That will be 170 yards from the surface. We are going to force the water direct to the surface, and the condensers will be fixed in the engine house down below. Where a large quantity of water is to be dealt with in sinking, it is best to start with a good pump erected on the surface.

Mr. MC.GEEVER seconded the motion, and said he found that bricking solid was the best. It might be a bit longer and dearer, though he questioned whether it was. They were much indebted to Mr. Keen, who had sunk two fine pits, and there was none better in Lancashire or elsewhere. He had not been selfish and deprived anyone of the privilege of looking around the pits, but had always welcomed visitors, and it was a great advantage to students to see the arrangements.

The motion was passed unanimously.

The CHAIRMAN: This question of sinking would form an admirable subject in itself for a debate. I do not think with regard to sinking with guides that there would be unanimity, although some of us would have a very strong opinion as to the increased safety of guides, and timbering in advance of the walling. As to skeleton rings I have seen several sinkings where they have been used, and can testify to their being a very great advantage. They make the work very much safer, and thereby expedite the work. I take Mr. Keen's allusion to packing, to refer to the soft, incohesive packing such as ashes which has so often times proved to be costly. We are all delighted to see Mr. Keen, and very grateful to him for having given us so much information.

Mr. KEEN, in reply, said within forty years there would be collieries all the way to Warrington, and every one of those places would have the same difficulty to contend with as they had had at Maypole. There was no doubt that coal was there, and money would be found to get it. As to the Chairman's remarks about safety, he had always considered safety as a primary object in what he had had to do; the tackle had been of the best, and everything had been done with a view to safety. He was much obliged to them for the vote of thanks. It had always been a great pleasure to him to give anyone any information he possibly could in reference to what he had learned in the sinking operations.

Mr. J. G. PATTERSON read the following notes on Howat's Latest Safety Lamp, fitted with Patterson's arrangement of gauzes:—

HOWAT'S LATEST SAFETY LAMP.

Fitted with Patterson's arrangement of Gauzes.

Exhibited and Described by Mr. J. G. Patterson.

In continuation of my paper* on Howat's Latest Safety Lamp—read before the Society at their last meeting—I desire to bring to your notice an improvement in the arrrangement of the gauzes.

It has frequently happened, notwithstanding the most stringent precautions, that lamps have passed into the pit without gauzes, to the imminent danger of life and property. Figs. 2 and 3 show Patterson's Patent Gauzes fitted to Howat's latest Lamp and to an ordinary Marsaut. With this arrangement of gauzes it is impossible to put a lamp together except in its complete state.

Fig. 2 shows Howat's Lamp as a bonneted clanny; M is the gauze with ring on, into which the glass fits; N is the case top or middle ring. This is bored out so large that whatever size of glass is used, should an attempt be made to fit the glass cylinder into the lamp, and the gauze wanting, the glass will fall into the bonnet or shield of the lamp, and thus show to the lampman in the most conclusive manner that something belonging to the lamp is not in its place.

Fig. 3 is a lamp with two gauzes fitted as a Marsaut. The case top or middle ring N is made the same as in Fig. 2. The rings or gauzes O and P are so made that when one gauze is inside the other, and in their proper place in the lamp, they form the seat for the glass cylinder; but should either or both gauzes be wanting, the glass will fall into the bonnet or shield of the lamp, and glass holder Q will screw

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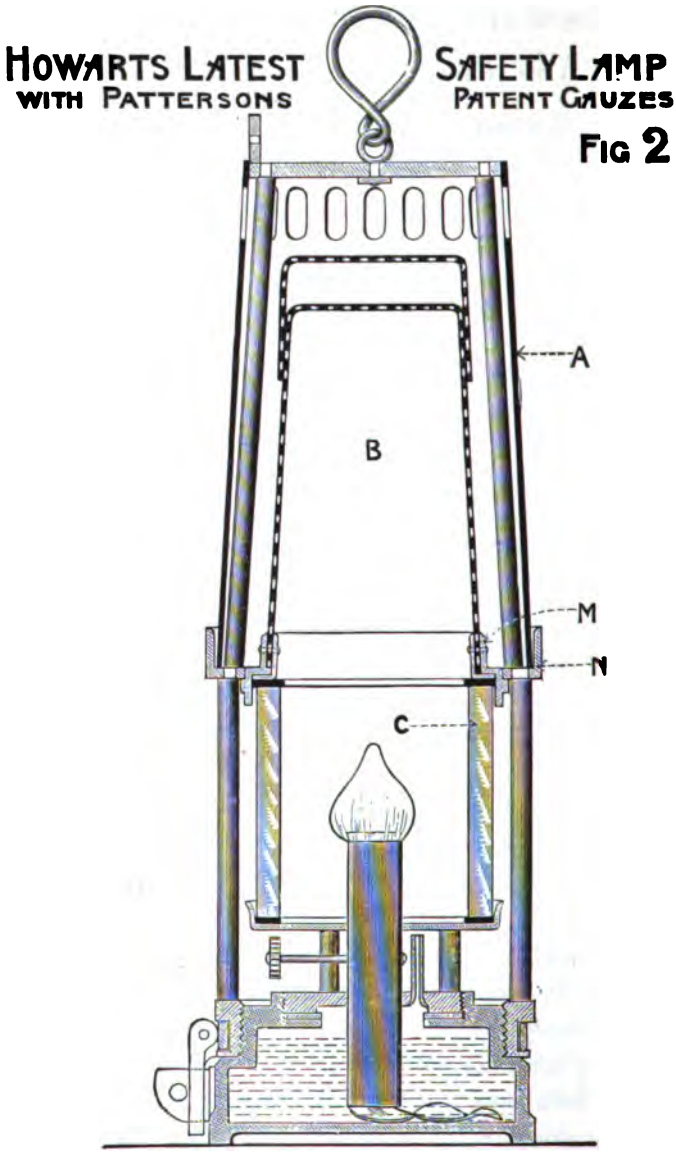
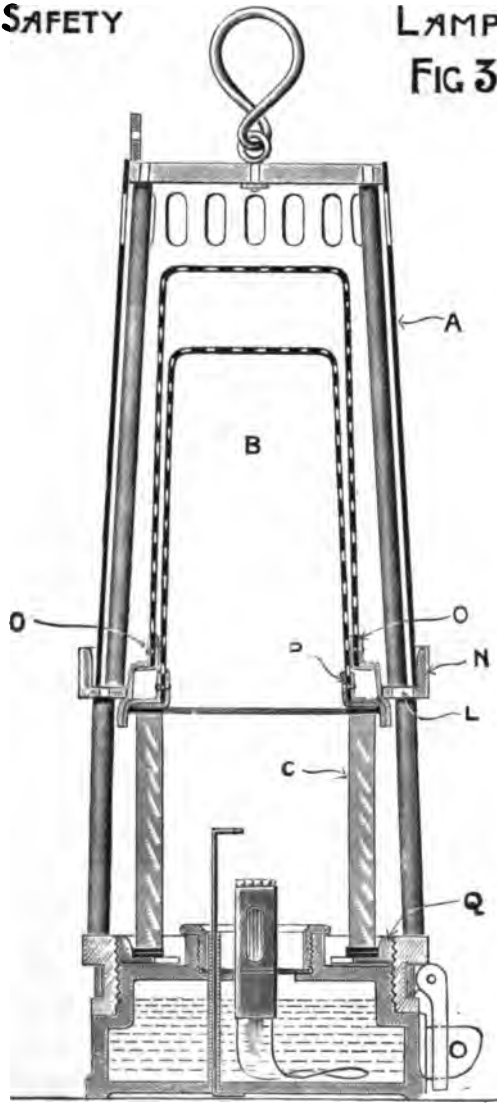
* Part XIII., Vol. XXVI., Man. Geol. Soc. Trans.


HOWARTS LATEST
WITH PATTERSONS
SAFETY LAMP
PATENT GAUZES
FIG 2
A
B
M
N
C


PATTERSONS PATENT MINERS
SAFETY LAMP
FIG 3
A
B
O
O
D
N
L
C
Q
O

right through into the lamp. Thus it is impossible to put the lamp together unless it is a complete and an actual safety lamp.

This arrangement does not complicate nor increase the number of parts of the lamp. The gauze rings will practically last as long as the lamp. When the gauzes are worn out the rivets are filed off and the rings put on new gauzes and rivetted again in the same holes. Existing lamps can be converted to this system.

Mr. KEEN: What is the price of the lamp?

Mr. PATTERSON: Six shillings, and with the electric light arrangement they are a shilling extra.

Mr. MATTHEWS: How many hours will they burn?

Mr. PATTERSON: The lamps will burn fourteen.

Mr. MC.GEEVER: What kind of oil is used?

Mr. PATTERSON: Paraffin.

The CHAIRMAN: What is the increased light of the paraffin?

Mr. PATTERSON: ·85.

The CHAIRMAN said there were two points that would be of interest to them. One was the increased amount of light, which was of so much importance in mining operations, so long as that increased light was accompanied by safety. The second point was of interest to himself and probably to all who believed that there should be a shield to every lamp going into the mine. An objection taken to that form of lamp was that the shield hindered the seeing of the gauze. Lamps had unquestionably been found in the mine in use

without gauzes, and it was an improvement in the construction of this lamp to render that impossible.

Mr. BURROWS proposed a vote of thanks to Mr. Patterson for exhibiting and describing the lamp, and said the question about the lamp gauzes had never struck him as a great difficulty, because if the lamp was examined by the fireman he could satisfy himself that it was all right. However, it was interesting to see that that was made even more certain. He did not think Mr. Patterson would say that when the two lamps were clean and new that lamp would give ·85 more light all the time. There was soot from the paraffin flame, and he did not think it was quite so clear that the light was so much better.

Mr. MATTHEWS seconded the motion, which was passed.

Mr. PATTERSON said when the illuminating power of the lamp was tested at the Gaythorn Gas Works, Manchester, a record was taken over 12 hours. At the commencement they lit the ordinary Marsaut lamp and measured one lamp against the other, the result at the commencement being as stated. As the test went on through the day the light of the Marsaut lamp diminished and the paraffin lamp did not. They could not measure it again with the Marsaut lamp at the end, but so far as they could see it gave as good a light as when it was first lighted. The paraffin light gave double the light of the Marsaut for the whole of the 12 hours. He knew a case in the North of England where a man worked his whole shift with a Marsaut lamp with no gauze in it, and it had been examined three times.

Mr. BURROWS: Was the bonnet loose?

Mr. PATTERSON: No; the bonnet was fixed.

The CHAIRMAN said he knew two cases where lamps had passed without gauzes, and been found in the workings of the mine. It always seemed easy to hold the lamp up and see the gauze. Nevertheless it had occurred, and some people had raised that objection to shielded lamps.

EXHIBIT.

Mr. GERRARD exhibited a specimen of iron ore from the Dover Sinkings, found at a depth of 592 feet, in the Oolite.

On the motion of Mr. BURROWS, seconded by Mr. WINSTANLEY, a vote of thanks was passed to Mr. Gerrard for presiding, and the meeting closed.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XV. VOL. XXVI. SESSION 1899-1900.

The ORDINARY MEETING of the Members was held on Tuesday, February 13th, 1900, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. W. S. BARRETT,
in the Chair.

THE GEOLOGICAL CONGRESS OF PARIS.

Mr. STIRRUP mentioned that he had received for distribution several copies of the Programme of Excursions in connection with the International Geological Congress, which is to assemble at Paris during the present year. A copy would lie on the table for the inspection of members of the Society.

ON NEW AND INTERESTING FEATURES IN TRIGONOCARPON OLIVÆFORME.

By Mr. George Wild.

Among the many interesting fossil remains of plant life found in the coal measures, there is one form with which most of the members will be more or less acquainted. It is the triangular cast of a nut-like seed known as Trigonocarpon.

These seeds are met with in almost every English coalfield in greater or less abundance, in both the sandstone rocks and the various shales. In the shales we generally find them much compressed from the shaly matrix being of a yielding nature. Yet, in such cases, the superficial markings are often preserved, and give a somewhat faint clue to their original form. If met with in strong sandy shale, the ridges formed by the angular character of the hard testa, or shell, are plainly discernible, converging to both ends of the fruit. If in the much softer shales, these lines are less prominent, owing to partial obliteration by pressure in the more yielding matrix. But, in the sandstone rocks, we find the casts have been protected by the readily-hardening character of the material in which they have been imbedded.

In the latter case, the external characters are often entirely obliterated by the destruction of the outer layers which originally invested the kernel or nucleus,* leaving nothing but a triangular cast of the inside of the shell or endotesta, and it is rare to find traces of the outer coverings.

* Figs. 1 and 2, Plate 2, are sketched from solid casts of the nucleus shown in examples before you, which also include the perispermic membrane, Fig. 2a.

The Peel Delf rock, near Worsley, in the Upper Coal Measures, and the Bardsley Delf rock, near Ashton-under-Lyne, in the Middle Coal Measures, have yielded a great many examples of these triangular internal casts. In the Lower Coal Measures, the Trigonocarpon is met with in the nodules of fossil wood where the structure of the outer investments is preserved, which exhibits the fruit very much nearer its original form than is the case in the sandstone casts or in the shale specimens. The fruit is known to palæobotanists as the Trigonocarpon olivæforme, and has been described by Prof. W. C. Williamson, and figured by him in his memoirs "On the Organization of the Fossil Plants of the Coal Measures," Part VIII., from good specimens furnished him by the late James Nield and Mr. John Butterworth.

The transverse sections from Mr. Butterworth's specimen show most of the features then recognised. The endotesta on its inner surface shows the three points in the nucular cavity, corresponding with the three prominent ridges on the outer surface, which, together with the nine less prominent ones, characterise this species, which in well-preserved specimens are enveloped in the sarcotesta or fleshy portion of the fruit or seed. The nucular and perispermic membranes are preserved, as is often the case, in a shrivelled state in the carbonate of lime and other mineral matter which has filtered in and filled up the interior.

In the vertical sections from Mr. Nield's specimen, the same organic features are met with, only being vertical, the angles and ridges which are a prominent feature in transverse sections are not perceptible from their running parallel with the length of the seed. The micropyle is shown for a distance above the tumid portion of the nucleus, but we are indebted to the transverse sections for a knowledge of its interior triangular character, which is continued a con-

EXPLANATION OF PLATE I.

FIG. 1.—Transverse section, near extreme tip of micropyle, associated with it are Myelopteroid leaves and triarch roots of Medullosa anglica (Scott) *e*, epidermis; *c*, cellular tissue; *m*, closed micropyle. X 2.

FIG. 2.—Transverse section, immediately below Fig. 1, associated with Myeloxyloid leaves, leaflets and triarch roots of Medullosa anglica. *e*, epidermis; *c*, cellular tissue; *m*, closed micropyle. X 2.

FIG. 3.—Transverse section, top of micropyle, associated with leaves, leaflets, and roots of Medullosa anglica. *e*, epidermis; *c*, cellular tissue; *m*, triangular micropyle. Associations as in Fig. 2. X 2.

FIG. 4.—Transverse section, top of endotesta, *e*, epidermis; *c*, cellular tissue; *m*, micropyle; *t*, endotesta. Associations as Fig. 2. X 2.

FIG. 5.—Transverse section, immediately below Fig. 4. *e*, epidermis; *c*, cellular tissue or sarcotesta; *t*, endotesta; *m*, micropyle. Associations as Fig. 2. X 2.

FIG. 6.—Transverse section, near base of micropyle, *e*, epidermis, *s*, sarcotesta; *t*, endotesta; *m*, micropyle. Associations as Fig. 2. X 2.

FIG. 7.—Transverse section at base of micropyle and top of nucleus. *e*, epidermis; *s*, sarcotesta; *t*, endotesta; *m*, micropyle. Associated with leaves and roots of Medullosa anglica. X 2.

Fig. 8.—Transverse section, below micropyle. *e*, epidermis, *s*, sarcotesta, *t*, endotesta; *n*, nucular cavity. Associated as Fig. 7. X 2.

FIG. 9.—Transverse section, body of fruit, *e*, epidermis; *s*, sarcotesta; *t*, endotesta; *n*, nucleus. Associations, leaves of Medullosa anglica. X 2.

Fig. 10.—Transverse section, middle of fruit; *e*, epidermis; *s*, sarcotesta; *t*, endotesta; *n*, nucleus. Associations, a second fruit in vertical section and leaves or petioles of Medullosa anglica. X 2.

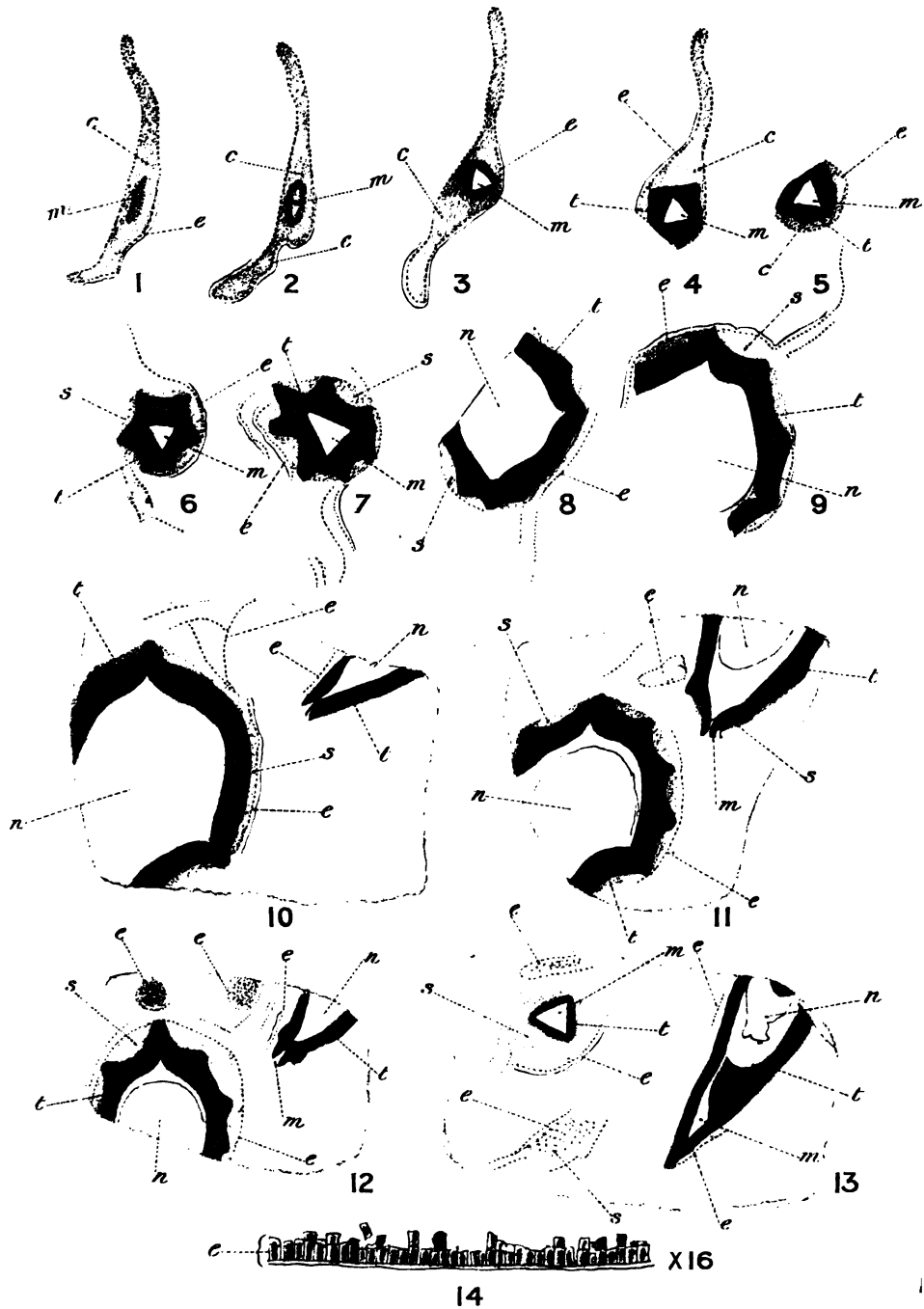
FIG. 11.—Transverse section of first fruit, also vertical section of second fruit with fragments of epidermal layer. *e*, epidermis; *s*, sarcotesta; *t*, endotesta; *n*, necleus. X 2.

FIG. 12.—Transverse section of first fruit, also vertical section of second fruit, and fragments of epidermal tissue belonging to top of a third fruit in transverse section. *e*, epidermis; *s*, sarcotesta; *t*, endotesta; *n*, nucleus. Associated with petioles and roots of Medullosa anglica. X 2.

FIG. 13.—Fragments of tissue at base of first specimen, also vertical section of the second specimen, and transverse section of top of triangular micropyle of the third fruit. *e*, epidermal tissue, *s*, sarcotesta; *t*, endotesta; *n*, nucleus. Associated with fragments of petioles and roots of Medullosa anglica. The vertical sections in Figs. 10, 11, 12, and 13, exhibit a closing apex of the micropyle. X 2.

FIG. 14.—Tissue of epidermis and cuticle from the upper sections and which persists throughout the whole series of specimens, enlarged about 16 diameters. *e*, epidermis (palisaded), and thin cuticle.

Trans. Man. Geo. Soc. Part XV. Vol. XXVI.
to Illustrate Mr George Mild's paper.



TRIGONOCARPON OLIVŒFORME.

siderable distance up the tubular or hollow portion of the micropyle, which, in the vertical sections figured by Professor Williamson, seem to be broken short, being less than one fourth the length of the seed proper.

From careful working out into 13 transverse sections of a well-preserved specimen I have met with, it is seen that the micropyle is prolonged upwards from the nucleus a distance equalling almost the length of the fruit, and its character becomes changed from a triangular-centred tube of sclerenchymatons tissue into a mass of cellular parenchymatons tissue, which, near the tip, forms a boss, from which two wing-like appendages project. Indications of these appendages are met with a short distance above the cellular tissue of the boss, and continue in a downward direction, in a somewhat deranged condition, a distance down the fruit The appendages, or extensions, stand out in almost opposite directions, in a slightly reflexed curvilinear form on one side to the extent of ·50 in., and on the other, upwards of ·25 in. from the centre of the oblong boss. The cortex or epidermal covering surrounds both boss and wings, and passing downwards, envelopes the triangular micropyle with its sarcotestal and endotestal tissues, and continues down and around the body of the fruit to its base accompanied by its very thin cuticle. The base of this specimen ended abruptly, without showing any point for attachment in the bracts of a strobilus, or to an axis, though some specimens of these fruits show a short chalazal extension.

My limited knowledge of botany does not enable me to draw scientific conclusions with regard to the plant which bore Trigonocarpa, though I have often found Myelopteris (Will.), now (Myeloxylon, Brongniart) associated with Trigonocarpon. Yet, if the first-named plant be a true fern, they cannot well be connected. The investing layer of these specimens at first sight reminds one of the appearance of the

EXPLANATION OF PLATE 2.

Fig. 1. Nucleus or kernel. Vertical. (Natural Size.)

,, 2. Nucleus or kernel. Oblique Transverse. (Natural Size.)

,, 3. Triangular cast within endotesta. Vertical. (Natural Size.)

,, 4. Transverse section of Fig. 1, showing perispermic-membrane. (Natural Size.)

,, 5. Transverse section of portion of nucleus. (Natural Size.)

,, 6. Transverse section of triangular cast. (Natural Size.)

,, 7. Fluted exterior of endotesta. (Natural Size.)

,, 8. Transverse section of endotesta with nucleus. (Natural Size.)

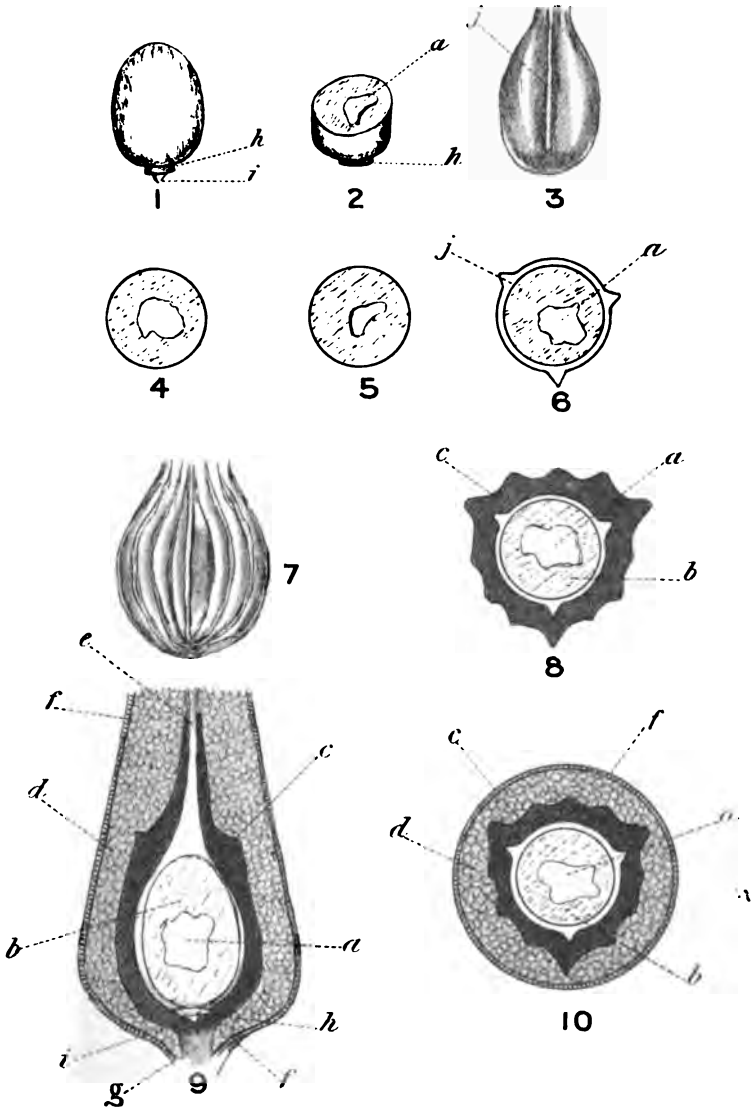
,, 9. Vertical section of fruit, restored. (Natural Size.)

,, 10. Transverse section of fruit, restored. (Natural Size.)

The letters indicating the several parts in the restorations, Figs. 9 and 10, are equally applicable to the rest of the figures on this plate, as follows:—*a* perisperm, *b* nuclues, *c* endotesta, *d* sarcotesta, *e* micropyle, *f* epidermis, *g* chalaza, *h* chalazal scar, *i* funicle, *j* internal angle.

PLATE 2.

Trans. Man. Geo. Soc. Part XV. Vol. XXVI.
to Illustrate Mr. George Wild's paper.



TRIGONOCARPON OLIVŒFORME.

palisade-like cortex of the lesser stems or twigs of Myeloxylon and Lyginodendron.

The upper portion of this investment is in a somewhat loose and disordered condition, probably owing to dessication of the once pulpy interior. The rupture of the inner epidermal covering on its inner side, leaves, in many places, an inward gaping, which would seem to indicate a loss of internal substance, an idea suggested also by the outer condition of the remainder of the sarcotesta, which seems as if in a decomposing stage from its structureless pulpy-looking character and difference in colour from the inner portion of the fleshy envelope surrounding and adhering to the shell or testa of the fruit, probably owing to maceration, exposure, or over-ripeness. Many of the ordinary sections, where the sarcotesta can be examined, exhibit this feature most markedly.

That this surrounding is not an accidental one, may reasonably be inferred from its being found to invest, more or less, in a similar manner, all three of the cluster of fruit found in this block or specimen; also from its being found enclosing only the substance of the fruit, except at the top of the micropyle, or where ruptured by shrinkage or other cause sufficiently to admit of the insinuation of foreign matter.*

Since the above was written, I find in Dr. Scott's memoir, just issued "On Medullosa Anglica, a new representative of the Cycadofilices," (a new plant which I obtained in nodules of fossil wood from near Stalybridge) the following remarks on the Myeloxyloid leaf-bases of this new plant. "In some places a more delicate parenchyma, forming an external layer outside the fibrous zone, is preserved, and no doubt this was always present during life. When this external parenchyma

* It is also found to agree closely with the epidermis of the Alethopteris leaflets.—G. W.

is well preserved it is found to consist of smaller and thin-walled cells, with abundant cell contents. The outer cortical layer, as well as the actual epidermis, had a well-marked palisade form. This external zone probably formed the assimilating tissue of the organ."

With very slight allowance, this description and the figure referred to in Dr. Scott's memoir agree almost exactly with the epidermal covering surrounding the specimens which form the subject of this paper.

This peculiar character of inner epidermis and surface cuticle, is not, so far as I am aware, found enveloping any fossil leaf or fruit except the Myeloxyloid leaf bases now proven to belong to Medullosa, and the frequent association of Trigonocarpon with fragments of Myeloxylon and allied structures, inclines me to believe in their ultimate connection.

I have often thought that the usual condition of the cellular tissue of the sarcotesta of the Trigonocarpon seemed short of finish, from want of a limiting epidermis and cuticle.

It is not unlikely that the carbonaceous markings of these exterior envelopes surrounding the fleshy coverings of this fruit, led Professor Newberry to say of his example of Trigonocarpon olivæforme (see Williamson's Organization, Part VIII., page 249) that it "has suffered little injury beyond the loss of the fleshy envelope. In this and some others I have seen, the three conspicuous salient ridges which traverse the surface longitudinally are shown to be the remains of broad and delicate wings, so delicate that they are generally torn away with the exception of their thickened bases."

Of course, from the structure-bearing specimens which up to that time, had been met with and investigated by

Professor W. C. Williamson, their condition led him to declare Professor Newberry's description to be a mistake. But as more perfect or better preserved specimens turn up, mistaken ideas arising from imperfect examples are often corrected.

Various remarks by authors seem to point to the difficulty of connecting these fruits with the plant that bore them, and my reason for bringing the discovery of these additional features in connection with it, is to assist, in however humble and small a degree, in the clearing up of this interesting geological problem.

Dr. Dawson's definition of Sigillaria, see Williamson's "organization of the fossil plants of the Coal Measures," Part VIII., page 226. "Fruit-scars in transverse rows or bands, each with a central vascular scar. Fruit,—Trigonocarpon, borne in racemes attached to the fruit-scars." Professor Williamson says:—"If Dr. Dawson is correct in making this last statement in reference to Trigonocarpon, all doubt as to the Gymnospermous character of Sigillaria should be at an end, because we cannot conceive of that seed belonging to any Cryptogamic plant. But I have yet seen no evidence whatever, either in his memoirs, or in those of Professor Newberry, who entertains the same opinion as Dr. Dawson does, that any such relationship exists. Under these circumstances, in the subsequent pages, I must include Trigonocarpon amongst the Gymnospermous plants, but must exclude the Sigillaria, and still regard the latter as Lepidodendroid Cryptogams."

On page 232 we find the following sentence in relation to Hooker and Binney's memoir on Trigonocarpon. "In this memoir the Trigonocarpon described, which appears to have been T. olivæforme of Lindley and Hutton, is shown to bear a close resemblance to the true drupaceous seeds of Salisburia

adiantifolio." On page 249 we find the following: "These Peel specimens usually resemble the nuts of the Salisburia sold in grocers' shops in China, but which are deprived of all their outer sarcotesta."

I have attempted a restoration on Plate 2, Figs. 9 and 10, from a study of the new features, the subject of this paper, and, since making the sketch my views on that point have been materially strengthened by a rough sketch made by Mr. R. Kidston, when explaining to him my ideas of the original form of the fruit. His sketch being that of restored Carpolithes alatus to which he compared Trigonocarpon.

I may here remark that the block containing the Trigonocarpon with the new features abounds in fragments of stem roots and leaflets now proven to belong to Medullosa by their connection with Myeloxylon its leaves.

From the study of structure-bearing specimens, it is found that the Trigonocarpon olivæforme as usually met with in beds of sandstone is only the internal cast of a stony endocarp, as before-mentioned, whose inner form was such that if filled in with mineral matter would form the mould for such a triangular cast. The outer form of this endocarp consisted of three prominent ridges corresponding in position with the three inner recesses, whilst between each principal ridge were three secondary ones, and enveloping this endocarp was a fleshy mesocarp consisting of cellular tissue of unascertained thickness. This mesocarp would appear, from the features described in this paper, to be surrounded by an epicarp consisting of epiderm and cuticle as before described, and shown in sections produced. The whole pericarp would give to the seed an outside character differing much from that conveyed by the shelly or stony endocarp.

This new feature, being of an unbroken epidermal character, would seem to preclude all doubts as to its being a natural and not an accidental envelope.*

Eight or nine years ago I obtained a few large blocks, or nodules, from a coalmine near Stalybridge, from which I cut and mounted a few sections, which, at the time, I took to be Heterangium, and labelled them as such, not knowing the characteristic features of Medullosa. These, the earliest sections cut from those blocks, are now in possession of the Manchester Museum authorities, Owens College.

From a careful study of a large number of sections from the blocks I have obtained from the above-named coal-mine, two prepared by myself, and the rest, nearly one hundred, most skilfully prepared by my friend, Mr. James Lomax, Moses Gate, Bolton, at the request of Dr. Scott, of the Royal Gardens, Kew, he having discovered that an unfinished section from the above-mentioned blocks, sent by Mr. Lomax to the late Prof. W. C. Williamson, contained a plant new to this country, as well as being a new species, has named it Medullosa Anglica. He, Dr. Scott, has made out the Cycadofilician character of the plant, connecting Myeloxylon (Brongniart) with it, as the leaves, and describing the roots and their manner of growth, from a section which I prepared from the block which furnished the before-mentioned excellent specimen in the Manchester Museum, as well as sections of lesser and extremely well-preserved triarch roots of the same plant, from the same specimen blocks, prepared by Mr. Lomax. It is also probable that the ultimate pinnules and leaflets

* Since the above was written I find, from slides I have prepared, that, in addition to the before-mentioned Myeloxyloid epidermis, that the outer or upper skin of the Alethopteris leaflets presents similar features, which if any connection existed would be quite natural. See Dr. Robert Brown, Science for All, Vol. II., Part 44, page 243: "The skin of the fruit is, of course, the epidermis, of which we have already had enough to say (Vol. I., page 20), and in nearly every respect agrees with that thin covering as found in the leaf."

will ere long be made out in their connection with this plant by the same author. I have prepared a series of sections of extremely good triarch roots of M. Anglica, three or four of which contain sections of leaves of Alethopteris connected with a Myeloxyloid midrib, and from the investigations and opinions expressed by Dr. Scott on the subject, the whole of the plant with the exception of the fruit, will shortly be satisfactorily understood.

It may be noted at this point, that both early and recent palæo-botanists are inclined to connect Trigonocarpon and Carpolithes with plants of Cycadean affinity. Since writing the description of the Trigonocarpon I have met with, I learn from Dr. Scott that another authority on palæo-botany, Mr. Hemingway, had conjectured, from their constant association, that this seed belonged to Alethopteris, a fern-like leaf or pinnule, which Renault has shown was borne by plants having a Myeloxyloid structure.

Since the above-named sections of the triarch roots of M. Anglica were prepared I have met with many others containing fragments of Myeloxyloid stems, and associated with them many leaflets of Alethopteris, some showing unmistakable evidence of not only Myeloxyloid midribs, but also that the upper surface of the leaflet bears a pallisaded epiderm and thin cuticle, strongly reminding one of the character of the investing tissue which forms the subject of this paper.

Should it eventually be proven that Trigonocarpon is the fruit of Medullosa, a most complete elucidation of the characteristics and nature of a highly complex fossil plant will have been arrived at.

It may seem, to students of recent botany, strange that the highly complex plant Medullosa of palæobotanists, a plant closely allied to Cycads and Ferns, and probably bearing

the nut-like Trigonocarpon with a cellular fleshy or drupaceous covering, should be thought to be the parent of the Cycads and Ferns of the present day, yet, the process of evolution, which is credited with the production of wonderfully varying generic branches from a common ancestor is almost universally accepted.

The sketches of some of the points mentioned, together with the sections on the slides showing them, will explain much of what may be left vague in my attempt to describe them.

I am indebted to Mr. Stirrup, Dr. Scott, of the Royal Gardens, Kew, and my friend Mr. John Butterworth, of Shaw, for encouragement to bring the subject before the Society; and to Mr. James Lomax for his kindness in preparing the photographs laid before you, connected with the subject.

Professor BOYD DAWKINS said: I am sure we have all listened with very great pleasure to Mr. Wild's paper. We welcome him again amongst us—he has been a stranger for some time—and I hope we may have many similar papers from him. As regards botanical details I do not feel in a position to deal with the subject, but it strikes me that this plant must certainly belong to the Gymnospermous division, and that it has no connection with any Lepidodendroid plant. The Gymnospermœ include the Cycads; therefore they would cover the Medullosa. The subject is a very interesting one, and I feel very much indebted to Mr. Wild for bringing it before us.

Mr. JAMES LOMAX said: I can only corroborate what my friend Mr. Wild has said, and the conclusions he has come to. All the sections I have yet made, and the material I have dealt with, tend to the one conclusion that this is the seed vessel of a Gymnospermous plant, and is, in fact, some-

what similar to the fruit of Cycads. In the present specimens of *Trigonocarpon olivæforme*, the external shell, or hypoderma, has the same kind of structure as the cortex, or hypoderma of the leaf stalk of *Medullosa anglica* [*Myeloxylon* or *Myelopteris* of Williamson]. There are also other affinities, which Mr. Wild has mentioned, such as the leaves and eet, which resemble some portion of the structure of the penduncle Trigonocarpon olivæforme. These agreements with the leaf stalk [*Myeloxylon*] and leaves which are of the *Alethopteris* type of Fossil Ferns, bear out to me conclusively that *Trigonocarpon olivæforme* is the fruit of *Medullosa anglica*. Of course it is not clearly demonstrated that this is so, but in all probability time will show it.

Mr. Joseph Dickinson: I have very great pleasure in moving a vote of thanks to Mr. Wild for his very valuable paper. It is a subject in which many of us cannot follow him. It is one with which only geologists of high standing can be acquainted. I may say that about twenty years ago, at what was called the Peel Sandstone Quarry, between Little Hulton and Tyldesley, a large number of these acorn-like seeds were found embedded in the sandstone. They were very plentiful indeed. The men called them sometimes nuts, and sometimes acorns; but they always appeared to me to resemble very closely the little bladders which are found on some species of seaweed.

Mr. Stirrup: In seconding the vote of thanks which Mr. Dickinson has proposed. I think we must all welcome our friend Mr. Wild's presence amongst us again. We are pleased to find that he has been diligent, during his absence, in working up some of those curious fossils of the Coal Measures, in the study of which he has had such a long experience. I did not quite gather, during the reading of the paper, what are the specially new features in regard to the Trigonocarpon. Is it the presence of the so called wings?

Mr. WILD: The wings favour the existence of an epidermis—they belonged to the fruit itself, and if they were opened out to the original circular form, which the fruit would present when growing, it would be found that they enclosed a softish sarcotesta and within that the shell. Being pressed together after decomposition of the soft tissue, they have been preserved in the form of wings.

Mr. STIRRUP: If that is the case, the wing-like expansion is certainly not a new discovery, so far as I can make out, for in some foreign works you may find figures of these fruits with winged appendages. They have been found, I believe, in some German coal pits, and also in America, possessed of the wings. The difficulty is to know to what plant they can be assigned. Many opinions have been expressed on this point, as Mr. Wild has mentioned. Hooker and Binney went into this subject years ago, and decided that *Salisburia adiantifolia* or *Ginkgo biloba* was the only living plant which had fruit most nearly allied to the Trigonocarpon. It is regarded as a sacred plant by the Chinese. The Ginkgo certainly is a gymnosperm, and belongs apparently to the yew tribe. As to Medullosa, I cannot speak from any experimental knowledge what it is particularly, but from the description given it certainly ought to be a gymnosperm. It certainly cannot be a fern, because we do not expect, in any extinct species of fern, to find such a fruit as the Trigonocarpon. But it is very gratifying to find that this subject has not been laid aside; that there is ample material yet to work at, and that there are possibilities still of discovering something new. I should like to remark that the Peel Quarry has been famous all over the country for these nuts or seeds, but they occur also in Scotland, and elsewhere. At Peel Quarry, however, they occurred in the greatest abundance. It is remarkable, as Mr. Dickinson pointed out, that they are in the sandstone in such quantity as would make it appear that

they have dropped from some overhanging tree into the soft sand, which has subsequently solidified. I would like to ask if any remains of Medullosa have been found in the sandstone strata in which these Trigonocarpons are found. I have never heard that anything of the sort has been met with there. It is very natural that any plants found to have been growing in the neighbourhood should be regarded as the probable parents of the fruits. I rose, however, to second the vote of thanks to Mr. Wild. I have particular pleasure in seeing him again amongst us, and hope he may be able to come oftener to our meetings.

The resolution was passed with acclamation.

Mr. WILD, in responding, said: In reply to Mr. Stirrup I would like to say that Dr. Scott, as well as the French palæo-botanists, has proved that medullosa contains three main steles, each of which is surrounded by secondary woody tissue, whilst outside all are three large leaf bases. The petiole has always been known to us, through Professor Williamson, as Myelopteris—a fern. The whole stem of Medullosa has the triangular character, on account of the three steles in the centre, and the large leaf bases that come out in succession up the thick stem of what is described as a Cycad. The Myelopteris of Williamson is really the stem and leaves of Alethopteris—formerly called Pecopteris—which we have always understood to be a true fern. The leaves are really fern-like, and a dozen slides which have been made show that the Alethopteris leaflet is the mid rib of Myelopteris or Medullosa, from Dr. Scott's description of it. Slides in my possession connect it with Cycadean affinities; he therefore declares it to be really Cycado-filicean in character—that is, connecting the Cycads and the Ferns.

Mr. LOMAX: Of course this is a matter of evolution. Dr. Scott has made out quite clearly that the two classes of plants—the two divisions which we get to-day—of Ferns and

Cycads were, in the Carboniferous age, united in one order, that is the axis or steles of *Medullosa anglica* was of the Cycadean order; whilst the petiole or the leaf stalk was of the Filicean order, and which has up to the discovery of the present *Medullosa anglica* been classed a true fern. Hence the name *Cycadofilices* which is given to this group of fossil plants. *Medullosa* has often been found in the Upper Coal Measures of the Continent, but never in the Middle Coal Measures. The specimens described by Mr. Wild are all British.

A New Specimen of Calamites with Roots.

Mr. Lomax called attention to a specimen which he had found in the Bolton Museum among a collection of *Calamitean* Casts, labelled "Calamite, from the Brassey Mine, Hollin's Fold." He said that, in a paper he read before the Society in June last, he mentioned the finding, in association with *Calamites*, of stems of *Astromyelon*, which turned out to be the roots of *Calamites*. In the specimen now shown, at the upper end there are three nodes of the true Calamatean type; below these there is a gradual tapering, which ultimately comes to a point. Between the point and the first true or ordinary node there are seven nodes which bear from six to two appendages or roots, which are truly Astromyelons. The specimen has been examined by Dr. D. H. Scott and other palæobotanists, who say that it is the first specimen of this character they have yet seen. Through the kindness of Mr. W. W. Midgely, F.R.M.S., the Curator of the Chadwick Museum, Bolton, the specimen is put in my hands to cut up in the best way to show the morphological structure of the tissues. He appealed to Colliery Owners and others connected with mines to keep a look-out for specimens bearing these characters. This one, he added, was unique. There was no such specimen in the British Museum.

Professor BOYD DAWKINS: Where did the specimen come from?

Mr. RIDYARD: I believe it is from the late Mr. Rooke Pennington's collection.

Professor BOYD DAWKINS: But what horizon is it from?

Mr. LOMAX The Middle Coal Measures.

Mr. STIRRUP: In the Peel Quarry we not unfrequently got Halonia branches, and I had always the impression that these nuts were the fruits of Halonia. The close association of the two things ought to have great weight.

Mr. WILD: The Halonia is proved to be a lepidodendroid fruiting branch. But the lepidodendron bears fine spores in its fruit, so it cannot be that.

NOTE.—Since the meeting, Mr. Lomax has cut the above specimen into various sections, and the structure has turned out better than what he expected; it also shows some tissues that he has not seen in any other Calamitean specimen. He has put it into the hands of Dr. D. H. Scott, of Kew, who has kindly undertaken to describe it.

ON THE SINKING OF No. 3 NOOK PIT BY THE ASTLEY AND TYLDESLEY COAL AND SALT CO., LTD.

With a Detailed Section thereof.

By Mr. GEORGE PEACE.

In bringing before the Society a detailed section of the sinking of the No. 3 Nook Pit, at the Astley and Tyldesley Collieries, Astley, I may say there are not many features of interest in connection with the sinking, but as I believe this is the deepest shaft sunk in the district to the Trencherbone Mine, it may be useful to place on record the particulars of the strata sunk through.

After passing a few yards of surface clay and marl, the Permian rocks passed through are of a total thickness of 19 yards. From this point the Coal Measures are entered, the first workable coal seam being the Worsley Four Feet Mine, which has been extensively worked in years gone by.

At a depth of 220 yards from the surface, the brown rock is met with, (about 30 yards thick) which contains a considerable quantity of water, and this was tunnelled through to carry the water met with in sinking to the pumps at the No. 1 Pumping Pit.

The other workable mines varied somewhat in distance from each other as compared with the sinking at Tyldesley, the tendency being for the mines to approach each other in somewhat of an irregular manner, on the deep.

Immediately above the Trencherbone Mine some very hard rock was met with, about 40 yards thick, whereas at Tyldesley, about 1,000 yards on the rise, there was practically no rock at all.

The actual time of sinking the whole distance of 707 yards was 41 months, which includes the time occupied in driving the tunnels to convey the water away. The Trencherbone Mine being met with at a depth of 696 yards.

The Contractor availed himself very largely of the improved machine drills, and this was particularly of advantage in boring the holes into which the iron plugs were inserted to carry the bricking rings. It was also found an advantage and much safer to line the unbricked portions of the shaft with wrought iron curbs and timber backing, which were taken out again as the brick work was put in.

The work was carried through without any serious accident.

A locked coil rope was used for winding, and found to be of great advantage, as the hoppit did not spin at all.

The sinking of the first 600 yards was accomplished with a pair of 16 in. double-geared engines, fixed between the pillars of the permanent engines, so as to be available for haulage afterwards. The permanent engines consist of a pair of 36 in. × 6 ft. winding engines, with inverted conical drum, to work at 100 lbs. pressure, and made by the Worsley Mesnes Ironworks Co , Ltd., near Wigan.

SECTION OF STRATA SUNK THROUGH BY THE ASTLEY AND TYLDESLEY COAL & SALT Co. LTD., AT THEIR No. 3 NOOK PIT.

60 yards on the rise of No. 2 pit.

Dip of Mine, due South, one in 6 to one in 5½.

Depth from Surface. Yds.	ft.	in.		Name of Strata.	Thickness of Strata. Yds.	ft.	in.
				Pit Top raised	5	0	0
				Soil	0	1	0
				Clay	1	1	0
				Gravely Marl	2	2	6½
			Permian.	Red Sandstone	2	2	11
				Red Metal	0	1	5
				Red Sandstone	2	0	1
				Red Rock (soft)	1	0	2
				Shaly Rock	2	0	10
				Red Metal	4	0	9
				Hard Brown Burr	0	0	8
				Red Metal	3	1	10
				Bastard Brown Burr	0	0	10
				Red Metal	2	0	10
				Blue Metal	0	1	6
29	2	10½		Coal	0	1	6
				Rocky Warrant	7	0	9
				Brown Burr	0	1	0
				Grey Leys	7	0	3
				Brown Rock	27	0	7
				Blue Metal	1	0	9
				Brown Rock	5	2	0
				Blue Metal	6	2	7
85	2	8½		Coal	0	0	11
				Warrant Earth	0	1	0
				White Rock	4	0	3
				Blue Metal	0	2	8

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.
			Grey Leys	5	1	3
			Black Bass	3	0	3
			Warrant Earth	2	0	9
102	1	3½	Coal	0	1	5
			Warrant Earth	1	0	0
			Blue Metal	7	0	10
			Black Bass	1	0	9
113	1	0	Worsley Four Feet Mine	1	1	1½
			Warrant Earth	1	2	3
			Blue Metal	1	0	2½
			Black Bass	0	2	0
			Coal and Brown Stone	0	0	8
			Warrant Earth	1	0	2
			Coal	0	0	4
			Warrant Earth	1	0	2
			Coal	0	0	4
			Rocky Warrant	2	0	0
			Blue Metal	4	0	6
			Black Bass	0	0	6
			Blue Metal	5	1	4
			Black Metal	0	2	0
			Blue do.	4	1	6
			Warrant Earth	1	0	11
138	0	0½	Coal	0	1	2
			Rocky Warrant	1	0	3
			White Rock and Metal Bands	0	2	11
			Blue Metal	0	1	9
			White Rock and Metal Bands	1	1	6
			Blue Metal	2	0	1
			White Rock	1	0	11
			Grey Leys	0	2	0
			Blue Metal	4	0	3
151	0	4½	Coal	0	1	10
			Bassey Warrant	1	1	9
			Coal	0	0	8

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.
			Warrant Earth	1	0	6
			Blue Metal	7	2	4
			Warrant Earth	0	1	10
			White Rock	0	0	10
			Blue Metal	2	1	10
			Coal	0	0	1
			Warrant Earth	1	0	0
			Blue Metal	27	1	5
			Black Bass	4	2	3
			Warrant Earth	5	0	6
			Blue Metal	0	0	6
			Warrant Earth	0	1	3
			Blue Metal	1	0	9
			Warrant Earth	1	0	4
207	0	7½	Coal	0	2	3
			Dark Metal	1	2	2
			Black Metal	4	0	0
			Blue Metal	1	2	1
			Grey Flue	3	0	8
			Grey Leys	4	2	3
			Grey Flue	0	1	10
			Brown Rock	0	2	11
			Grey Flue	0	0	6
			Brown Rock	14	0	9
			Red Metal	0	1	0
			Brown Rock	16	0	3
			Red and Blue Metal	0	0	7
			Warrant Earth	2	0	5
			Blue Metal	3	2	6
			Rocky Warrant	2	1	0
			Strong Blue Metal	1	0	11
			Rock Bind	2	0	8
			Brown Rock	0	0	5
			Rock Bind	0	0	8
			Brown Rock	0	0	7

Depth from Surface. Yds. ft. in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.
	Dark Metal	0	0	4
	White Rock	0	1	2
	Dark Metal	0	2	0
	White Rock	0	0	4
	Dark Metal	7	1	6
	Light Warrant Earth	2	0	6
	White Rock	0	0	11
	Blue Metal	2	2	4
	White Rock	1	1	7
	Blue Metal	1	1	10
	Black Bass	0	0	3
	Coal	0	0	3
	Dirt	0	0	3
	Coal	0	0	3
	Dirt	0	0	6
	Coal	0	0	3
	Black Warrant Earth	0	1	5
	Grey Leys	0	0	10
	Stone Bind	1	1	2
	Blue Metal	2	0	8
	Black Bass	0	1	4
	Coal	0	0	2
	Warrant Earth	1	2	10
	Brown Burr	0	0	5
	Stone Bind	0	2	9
	Strong Blue Metal	1	1	1
	Brown Burr	0	0	7
	Stone Bind	0	1	8
	White Rock	0	1	8
	Strong Stone Bind	3	1	11
	Coal	0	0	1
	White Warrant Earth	1	0	8
	Black Warrant, with Iron Bands	1	0	1
	Black Bass	1	2	11
	Blue Metal	1	2	7

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.
			Black Bass	1	0	9
			Coal	0	0	7
			Warrant Earth	0	2	9
			Rocky Warrant	0	1	0
			White Rock..	3	2	0
			Grey Leys..	1	0	5
			Linsey	0	2	10
			Dark Metal	0	1	9
			Coal	0	1	9
			Dirt	0	0	3
			Coal	0	0	4
			Dirt	0	0	5
			Coal	0	0	11
			Dark Shaly Warrant	1	1	3
			Black Bass	0	0	5
318	0	6½	Good Coal..	0	2	3
			Black Warrant	0	1	6
			Rocky Warrant	0	1	0
			White Rock..	2	0	0
			Rocky Flue	1	2	2
			Blue Metal with Iron Bands	10	2	1
			Dark Metal	3	2	2
337	1	11½	Coal	0	1	6
			Warrant Earth..	1	0	3
			Coal with Bassey Tops	1	0	2
			Warrant Earth..	0	1	0
			Coal	0	0	4
			Warrant Earth..	0	0	4
			Coal	0	0	2
			Warrant Earth..	0	1	11
			Binn Rock	10	1	4
			Rock Bind	2	1	6
			Strong Grey Leys	1	1	3
			Dark Metal	0	1	0
			White Rock..	1	1	3

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.
			Dark Metal	1	0	4
			Bassey Metal	0	1	3
			Bastard Cannel..	0	0	6
			Coal	0	0	6
			Dirt	0	0	3
			Coal	0	0	11
			Bastard Cannel..	0	0	5
			Warrant Earth	0	1	2
			Metal with Iron Bands	4	1	1
			Black Bass	0	0	3
			Dark Metal	0	1	10
			Blue Metal	3	0	8
			White Rock	0	1	3
			Grey Leys	0	2	11
			Blue Metal	3	1	0
			Binn Coal, Tops	0	1	8
			Do. Dirt	0	1	7
			Do. Coal	1	0	1
			Do. Dirt	0	0	1
375	0	8½	Do. Coal	0	0	6
			Rocky Warrant	0	2	10
			Do. Flue	2	0	9
			Blue Metal, with Iron bands	6	0	0
			Black Bass	1	0	3
			Dark Metal	0	1	8
			Bassey Metal	2	2	9
			Blue Metal, with Iron bands	2	0	4
			Black Bass	0	1	6
			Strong Grey Leys	0	2	1
			Black Bass	0	1	8
			Rock Leys	1	2	6
			Strong Metal, with Iron bands	4	0	3
			Shale..	0	0	3
400	0	10½	Crombouke Coal	1	1	4
			Dirty Coal..	0	2	0

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.
			Soft Warrant Earth	1	0	10
			Stronger do.	1	1	6
			Shaly Metal..	0	2	7
			Blue Metal, with Iron bands	1	2	9
			Black Bass	0	2	0
			Coal	0	1	7
			Bassey Coal and Warrant	0	0	8
			Dark Warrant Earth	0	1	10
			Light do.	1	1	2
			Dark Warrant Earth, streaked with Coal	2	0	10
			Brassey Coal, Tops	0	1	7
			Do. Dirt	0	0	6
413	2	8½	Do. Coal	1	0	0
			Warrant Earth..	0	2	6
			Strong Metal, with Iron bands	6	1	9
			Black Bass	0	0	6
			Warrant Earth	0	1	6
			Strong Metal	0	2	6
			Do. Burr	1	1	3
			Strong Metal, with Rock bands	9	2	0
			Coal	0	0	11
			Dark Metal	2	0	0
			Six Feet Mine, Tops	0	2	6
			Do. Black Bass	0	1	2
			Do. Warrant Earth	0	1	0
			Do. Coal..	0	0	4
			Do. Warrant Earth	1	1	9
440	2	7	Do. Bottoms	1	1	3
			Black Bass	0	1	2
			Warrant Earth..	1	1	3
			Black Bass	0	1	7
			Warrant Earth..	2	2	0
			Coal (inferior)	1	0	3
			Soft Dirt	0	1	0

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.
			Flaggy Rock..	0	2	0
			Strong Metal, with Iron bands	1	1	0
			Grey Rock	0	1	8
			Strong Metal	2	2	4
			Dark Motal, with Iron bands	1	2	9
			Coal	0	0	8
			Warrant Earth	1	2	3
			Soft Dirt	0	0	9
			Strong Metal (Iron balls)	1	1	6
			Strong Blue Metal	1	2	0
			Flaggy Rock..	0	0	6
			Burr (light coloured)	0	2	9
			Rock (bed)	0	1	2
			Metal (bullion)..	0	1	2
			Strong Linsey	0	2	0
			Rocky Metal	0	1	4
			Grey Rock (good bed)..	0	2	0
			Burr (parting)	0	0	6
			Blue Metal	5	0	0
			Black Bass	0	0	7
469	2	4	(A) Coal (poor quality)	0	2	6½
			Dirt	0	0	10
			Warrant	0	1	3
			Blue Metal	3	1	3
			Coal	0	2	1
			Warrant	0	0	10
			Metal, with rock beds..	5	2	3
			Coal	0	1	2
			Dirt	0	0	4
			Coal	0	2	5
			Warrant	1	2	0
			Coal	0	0	4
			Warrant	0	0	9
			Metal	0	0	11
			Rock	14	1	10

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.
			Blue Metal	3	0	3
			White Coal (good)	1	0	0
			Warrant	0	0	4
			Coal (inferior)	0	1	11
			Warrant	0	2	11
			Black Coal (inferior)	0	2	3
			Warrant	0	1	11
506	0	10	Coal	0	0	8
			Warrant	1	0	9
			White Rock	5	2	5
			Black Bass	0	0	11
			Warrant	1	1	4
			Blue Metal	6	2	2
			White Rock	26	0	4
			White Rock, with carbonaceous partings	1	1	2
			White Rock, with Burr	13	2	4
			Blue Metal	2	0	1
			Coal and Dirt	0	0	3
			Blue Metal, with Burr balls	1	2	6
			Blue Metal	2	2	0
			Grey Leys	1	1	6
			Blue Metal (with iron bands)	1	2	10
			Dark Metal	14	1	0
			Coal	0	0	7
			Warrant	0	2	11
			Blue Metal	1	0	0
			White Rock	1	1	0
			Grey Leys	1	1	4
			Blue Metal	2	2	5
			Coal	0	0	3
			Black Bass	2	2	0
			Coal	0	0	1
			Warrant	0	0	9
			Coal	0	0	5
			Warrant	0	0	5
			Rocky Warrant	0	2	8
			Blue Metal	8	1	7
608	2	4	Coal	0	2	6
			Warrant	0	0	9
			Rocky Warrant	2	2	1

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.
			Rock (fine grit)	3	0	8
			Blue Metal	3	1	0
			Warrant	0	0	9
619	0	10	Coal	0	2	3
			Warrant	2	2	5
			Blue Metal	1	1	11
			Rock..	1	0	11
			Metal (with iron bands)	1	1	4
			Dark Metal	2	2	10
			Coal	0	0	3
			Warrant	1	2	0
			Metal (strong)	3	2	3
			Rocky Metal	1	2	0
			Rock	1	2	0
			Hill Hole Mine, Coal	0	0	6¼
			,, Dirt	0	0	1½
			,, Coal	0	2	0
			,, Bone	0	0	1
639	0	10¼	,, Coal	0	0	4½
			Warrant..	2	0	0
			Blue Metal	6	2	6
			Coal	0	0	1
			Dirt	0	0	1
648	2	6¼	Coal	0	2	0
			Warrant	1	1	5
			Blue Metal	4	1	2
			Grey Flue, with Burr beds	20	0	3
			White Rock	1	1	11
			Flaggy	3	1	10
			White Rock, with Burr	10	0	3
			White Rock	3	2	0
694	0	11¼	Trencherbone Coal (adjoining a want).	0	2	7
			Black Metal..	1	0	1
			Blue Metal, with streaks of coal	3	0	1
			Basses	0	0	6
702	0	3¼	Coal (inferior) and Dirt	3	1	8
			Blue Metal	9	0	0
711	1	7¼	Coal (good)	0	1	4

Mr. BURROWS moved a vote of thanks to Mr. Peace. He said: Mr. Peace is very modest, and made the paper short, but one very interesting point arises which is well worth notice from a practical point of view—that is, the question of the rate of dip. Our colliery is north of Mr. Peace's, and our dip is greater than his, and it is growing flatter, as he says, near the Nook pits. That opens up the question of what will be, in future, a very large coalfield under Chat Moss. If the dip had kept as we had it, one in five, or one in eight, the depth near Warrington would have been enormous; but, if the dip is getting flatter, the mines under the Moss, towards Warrington, may not be so deep as we have always thought. That would make a very great difference to the coalfields of Lancashire.

Professor BOYD DAWKINS: I second the proposition, and would just say that I am very glad indeed to hear what has been said by the proposer of it, with regard to the flattening of the dip. I have reason to believe that the seams are not so deep between Warrington and the border of the coalfield as is usually supposed; for I do know that some of the Red Upper Coal Measures with Spirorbus have been struck at Winwick, not very far from the area where the Warrington Corporation are getting their water supply. It would not be the case if the dip were continued.

The vote of thanks was unanimously passed, and Mr. Peace having acknowledged it,

Mr. DICKINSON said: I would like to say a word or two with reference to what Mr. Peace says in his paper, that the seams approach nearer to each other at the dip. Some of that is accounted for by a change in the thickness of the strata, but some of it is also due to the flattening of the measures. Where the measures are steep the distance between the seams, in sinking, is augmented in consequence,

Mr. Burrows mentioned the dip they have at Atherton. which is rather steeper, but in coming eastwards they get much steeper still. For instance, the Pendlebury dip is about one in 3½, and at Pendleton it is rather steeper than that. At Wigan, on the other hand, many of the mines are comparatively flat, which accounts for some of the difference in the distance between the mines, as they flatten out at the dip. With reference to what Professor Boyd Dawkins has said, underneath the land adjoining Chat Moss there is an estate belonging to one of our members, Mr. Lees Knowles, M.P., in which, a few years ago, during his father's lifetime, there was a very large issue of fire-damp, coming through the ground to the surface, and that had been going on for a long time.

Professor BOYD DAWKINS: Through the red rock?

Mr. DICKINSON: Coming to the surface, through all the overlying measures; and the late Mr. John Knowles was afraid it would be impoverishing the coal from which it was coming, so he had it stopped. I should like to mention that in this section of Mr. Peace's the Peel Delph rock was passed through, and Mr. Peace tells me that he found some of those fossil fruits of which we have heard. It is one of the rocks not very far from the White Mine and the Black Mine coal.

EXHIBIT.

Mr. WILLIAM SAINT exhibited a number of fossils found in the Millstone Grit in Rossendale.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVI. VOL. XXVI. SESSION 1899-1900.

The ORDINARY MEETING of the Members was held on Tuesday, March 13th, 1900, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. W. S. BARRETT,
in the Chair.

NEW MEMBER.

The following gentleman was balloted for and duly elected a member of the Society :—

Mr. W. OLLERENSHAW, Manager, Denton Colliery, Denton.

Mr. W. F. HOLROYD, F.G.S., read the following paper on "Some Further Notes on the Sea-beach in the Carboniferous Limestone, Derbyshire :—

SOME FURTHER NOTES ON THE SEA-BEACH IN THE CARBONIFEROUS LIMESTONE, DERBYSHIRE.

Illustrated by Diagrams, Microscopic Sections, and a collection of Polished Specimens.

By Messrs. J. Barnes, F.G.S., and W. F. Holroyd, F.G.S.

Read by Mr. W. F. Holroyd.

In December, 1896,* a paper was read by us upon the occurrence of a sea-beach at Castleton, Derbyshire, of Carboniferous Limestone age, in which we showed by the evidence of rolled shells, &c., that the upper beds of limestone in that locality were laid down in a shallow sea.

On March 6th, 1897,† we had the pleasure of bringing to your notice another paper in which we showed that well-rolled fragments of a fine-grained limestone of a different colour and texture to the general matrix were to be found embedded in the rock, sometimes so abundantly as to form a pudding-stone or conglomerate, and also that the rock was distinctly oolitic. This rock lies about half-a-mile to the west of Windy Knoll, and is also found at Sparrow Pits.

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* Trans. Man. Geol. Soc., Part IV., Vol. XXV., page 119.

† Trans. Man. Geol. Soc., Part VII., Vol. XXV., page 181.

Again, on the 15th June, 1897,* we read some notes on a favourable criticism of our papers by Professor Hull, in which we mentioned that some fossil foraminiferal forms had been found in the rolled and water rounded pebbles.

At the request of your Secretaries we again appear before you to add something to our former papers upon these interesting phenomena, and in the first place we may say that the list of the localities in which these rolled shells and water-worn pebbles, &c., have been observed, has been much extended.

They have been found over nearly the whole outcrop of the Derbyshire Limestone area, and as you will see from the map that is a very large area, and the probable reason why they do not occur over the entire area of the limestone is, that in some localities the upper beds which contained them have been removed by denudation. Further afield, the same conditions have been noted at Grassington, in Wharfedale, in the North of England; at Bolland, in North Lancashire; at Bristol, in the rocks forming the gorge of the Avon; and in North Wales, at Eglwyseg.

Most particularly are they to be found near the line of junction with overlying shales, and this seems to prove that the rolled shells and pebbles and oolitic rock are characteristic of the upper part of the Carboniferous Limestone as exposed in England.

Secondly, we are now able to fill up a most important gap in our former papers, and notably with regard to the age of the limestone pebbles forming the pebbly conglomerate found at Windy Knoll, at Sparrow Pits, Bradwell, and other

* Trans. Man. Geol. Soc., Part XI., Vol. XXV., page 308.

places (specimens of which are shown). The matrix of these specimens is made up of fragments of shells and oolitic grains, concretions of the oolite being very clear and easily defined, and through the rock there are interspersed numerous well rounded pebbles of various sizes from half an inch to four inches in diameter, of a fine grained very compact dark coloured limestone. We sought to account for the presence of these pebbles in the rock, and came to the conclusion that they must have been derived from some previously existing and older limestone rock. To what geological period this limestone belonged, whether Silurian, Devonian or Carboniferous, we were not then in a position to say, but suggested that a microscopical examination of the rock might possibly throw some light upon the matter, and settle the origin of the pebbles.

Latterly, we have been making a microscopical examination of thin sections of these pebbles, and also of sections of the upper limestone rock, and we find that they both contain the same species of foraminifera.

Under the two microscopes on the table you will find slides containing first, a section of the undoubted limestone rock of the upper beds, and second, a section of one of the pebbles. As both these sections show the same species of foraminifera, and further, as the forms of life shown are specially characteristic of the Carboniferous Limestone, there seems to be no doubt left that this determines the age of the pebbles, and confines them to the earlier periods of the Carboniferous Limestone age, and shows plainly that they have not been derived from Silurian or Devonian rocks as might have been the case.

On comparing the contents of the pebbles and those of the upper limestone, we find that there is a very fair number

EXPLANATION OF ACCOMPANYING PLATE.

MICRO-PHOTOS OF FORAMINIFERA FROM THE CARBONIFEROUS LIMESTONE OF DERBYSHIRE.

Fig. 1. X 40. Endothyra ammonoides (*Brady*) from pebble.

,, 2. X 20. ,, ,, ,, ,, limestone.

,, 3. X 25. Textularia eximia (*d.'Eichwald*) from pebble.

,, 4. X 20. ,, ,, ,, ,, limestone.

,, 5. X 30. Endothyra Bowmani (*Phillips*) from pebble.

,, 6. X 30. ,, ,, ,, ,, limestone.

,, 7. X 40. Trochammina incerta (*d.'Orbigny*) ,, ,,

,, 8. X 13. ,, filum (*Schmid*) ,, ,,

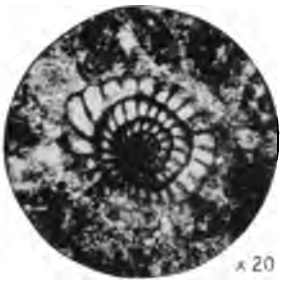
,, 9. X 30. Endothyra radiata (*Brady*) ,, ,,

,, 10. X 12. Nodosaria radicula (*Linné*) ,, ,,

,, 11. X 20. ,, ,, ,, from limestone, same figure enlarged.

,, 12. X 30. Valvulina Youngi (*Brady*) ,, ,,

1



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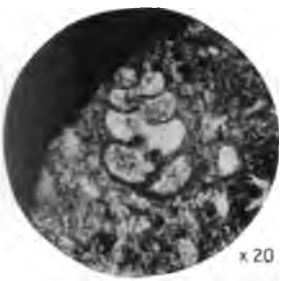

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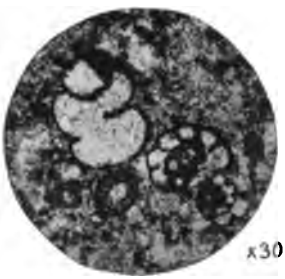

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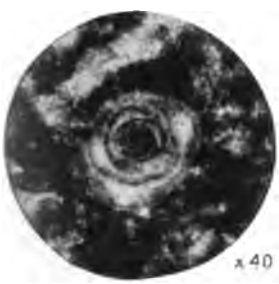

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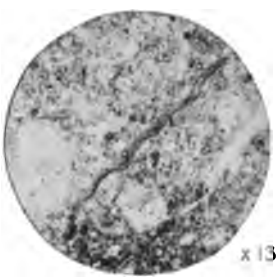

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FORAMINIFERA FROM THE CARBONIFEROUS LIMESTONE OF DERBYSHIRE.

of species represented out of the list of known Carboniferous foraminifera.

Foraminifera are minute organisms, mostly marine, and vary in size, with a few exceptions from $\frac{1}{100}$ to $\frac{1}{10}$ of an inch in diameter.*

The smaller foraminifera occur in the older rocks. In the newer rock, such as the Cretaceous, we have them reaching an inch in diameter.

Their range in space is extensive. They are found in every ocean, mostly near the surface; only a few rare forms living in deep water.

They are also very abundant in shallow water. Their range in geological time is also extensive, beginning in the Cambrian and persisting through all the geological ages up to the present.

The genera of these minute creatures, as represented in the Carboniferous system, are few in number, and the species are not very numerous. Many of them are very local, and some extremely rare, so that for comparative purposes the list in any given locality is not a very lengthy one.

On the blackboard we have a list of the chief divisions of the Carboniferous Rhizopod fauna.

Speaking generally, we may say that foraminifera are divided into two sub-orders, those with non-porous or imperforate and those with porous or perforate tests. The imperforate tests are of two kinds, one of which has opaque porcellanus shells of very fine texture, the other has a chitinous layer cementing sand-grains or similar extraneous bodies.

* Nicholson's Manual of Palæontology.

The following table shows the genera of the Carboniferous foraminifera* :—

Sub-order Imperforata :—

Families—Gromida .. .. No fossil forms.

Lituolida .. .. Saccammina. Lituola. Haplophragmium. Trochammina. Climacomina. Valvulina. Endothyra.

Miliolida.. .. .. .. No fossil forms.

Intermediates .. .. .. Nodosinella. Stacheia.

Sub-order Perforata :—

Families—

Lagenida .. .. Lagena. Nodosarina— Nodosaria. Deutalina.

Globigerinida .. Textularia. Bigenerina. Truncatulina. Pulvinulina. Calcarina.

Nummulinida .. Archœdiscus. Amphistegina. Nummulina. Fusulina.

The above list embraces forty species.

* "Brady," "Carboniferous and Permian foraminifera" Monog. Palæontograph Soc.

It is important to notice that the Endothyra is the most prominent fossil form, in fact it is an essentially Carboniferous type.

Valvulina and Trochammina are also common and characteristic types, and these are the three main forms found commonly in the limestone rock and in the pebbles. The whole series of foraminifera is much more common in the upper beds of the Mountain Limestone, and in the Yoredale limestone and shales, than in the lower beds, and only Saccamina, Endothyra, Valvulina, and Trochammina appear to be regularly distributed throughout the limestone deposit. One genus, Fusulina, not recorded from British Carboniferous strata, is said to make up the bulk of the limestone of Russia and of the United States.

The older rocks, such as Silurian and Devonian, contain only a few species, but as we ascend the geological scale, the number of species, size, and importance of the forminifera increases in a very rapid manner, until we find them as very extensive rock builders in the Cretaceous and Eocene ages. The genera and species found alike in the limestone and the pebbles are:—

Endothyra Bowmani.	Valvulina bulloides.
Endothyra ammonoides.	Valvulina Youngi.
Saccammina Carteri.	Stacheia.
Trochammina anceps.	Textularia eximia.
Trochammina incerta.	Nodosaria radicula.

The following is the list of species detected in both the pebbles and the limestone, and doubtless there are others which may have been overlooked:—

Endothyra Bowmani.
„ ammonoides.
„ globulus.
„ crassa.
„ radiata.
Saccamina Carteri.
Valvulina palœotrochus.
„ bulloides.
„ Youngi.
„ decurrens.
Trochammina filum.
„ anceps.
„ centrifuga.
„ incerta.
Dentalina (?)
Nodosaria radiata.
Lituola Benneana.
Textularia eximia.
„ gibbosa.
Stacheia marginulinoides.
„ acervalis.
„ pupoidea.
Calcarina ambigua.
Nodosinella concinna.
Lagena Parkeriana.
Archædiscus Karreri.

One of the specimens of limestone from which several slides have been made contains a number of branches of coral of the kind known as Syringopora geniculata. The interspaces are crowded with well preserved foraminifera of various kinds but chiefly Endothyra and Trochammina.

It is interesting to note that the limestones laid down in deep waters are fairly homogeneous in structure, that is, they present a fairly uniform fine grained texture, whilst those deposited in shallow water present the greatest variety, varying from coarse conglomerate to fine grained oolitic detrital and mosaic limestones.

We have polished specimens upon the table which show these varieties, chiefly from the Derbyshire area.

Summarising the facts fairly deducible from the observations made upon foraminifera in the pebbles and the limestones, it may be said that the older portions of the Carboniferous Limestone formation must have been deposited, consolidated, and exposed to denudation. The fragments of this rock which were dislodged were then exposed to the

action of the waves and tides of the sea, and were rounded by attrition, and then re-deposited to form part of the material of the newer portion of the formation. The length of time which must have elapsed between the commencement and termination of the limestone deposit is beyond all terms of years to express. It must have been very great. This then is the explanation of finding the dark coloured limestone pebbles embedded in the lighter upper limestone, and the fact of the foraminifera being so abundant in the interspaces of the coral growth shows that the later deposits, at all events, were laid down in the shallower waters of the Carboniferous sea, and we may say that not only have we settled the origin of the pebbles, but also in so doing have brought to notice the presence of one half the figured species of foraminifera, as occurring in the limestone of the Derbyshire area. Hitherto the specimens described and figured have mostly been obtained from the North of England, from Scotland, and from Ireland. With the exception of a few specimens from Bakewell, no mention is made in records with which we are acquainted of any from the Derbyshire Carboniferous Limestone.

The PRESIDENT said this was not the first time that Messrs. Barnes and Holroyd had given the Society the benefit of their investigations. They all greatly regretted the absence of Mr. Barnes, especially when they learned that illness was the cause. To him the paper had been of very great interest.

Professor BOYD DAWKINS said he had listened with the greatest possible pleasure to the valuable communication which had just been read, and felt that Mr. Holroyd, in conjunction with Mr. Barnes, in bringing this as one of a series of communications was really acting up to the old

traditions of the Society. He considered that a paper of this sort, full of local work and local colour, and scientifically accurate, was about one of the best contributions that could be made to science. With regard to the subject-matter of the paper, he was perfectly astounded to find so many of those forms of life in the Carboniferous Limestone of Derbyshire. There was one point on which he would venture a remark. He was not certain that the pebbles exhibited by Mr. Holroyd might not have had the same kind of history as that which he had observed in other pebbles. These consisted of carboniferous mud which had been rolled on the sea shore, and the surface of them has been covered with sand, but now they were perfectly hard rock. He thought it possible that when those on the table were converted into pebbles they were not in a hard crystalline condition but that they might have been formed while they were a calcareous paste.

Professor DAWKINS moved a vote of thanks to Messrs. Barnes and Holroyd, and again expressed his opinion that the work which these gentlemen had done with regard to the limestone was very valuable.

Mr. C. R. LINDSEY seconded the motion which was cordially adopted.

Mr. JOSEPH DICKINSON, F.G.S., said he noticed that the Geology of Castleton had been brought before the North of England Mining Institute of Engineers, by his old friend and colleague, the Inspector of Mines in Derbyshire, and in one part of his paper he alluded to the communication brought before the Manchester Geological Society, by Messrs. Barnes and Holroyd. He said: "Those who have studied the palæontology of the Mountain Limestone will have no difficulty in assigning its origin to marine conditions, and those who desire to question whether the limestone was a

deep or shallow sea deposit at Castleton, should examine the small quarry, about half way between Castleton and the Speedwell Mine, on the left hand side of the road leading from Castleton to the Winnatts, where Messrs. J. Barnes and W. F. Holroyd state that the remains of a sea-beach appear in the limestone formation, and from this it is supposed, that whether the lower limestone be a deep sea deposit or not, the upper beds round Castleton must have been deposited in shallow water." The view here expressed coincided with what Mr. Holroyd had just stated, namely, that this, what they might call sea-beach, was originally in shallow water. In reference to the question of the origin of the peculiar pebbles in the limestone he wished to ask whether they could not be accounted for by the aggregation of silicious matter in the process of crystallisation of the rock instead of supposing them to have come from some distant place.

Mr. Holroyd thanked the members for their cordial reception of the paper, adding that the providing of the materials for the paper and the frequent journeys of Mr. Barnes and himself to Derbyshire which the work had entailed upon them had been a great pleasure to both of them.

The thanks of the Society are also due to Mr. C. R. Lindsey for his kindness in preparing the admirable micro-photographs of the foraminifera which illustrate the paper.

RESUMED DISCUSSION ON PIT PROPS AND THEIR SETTING.

By Mr. Joseph Dickinson, F.G.S.

In the brief discussion when the paper was read on November 14th last, some members expressed the hope that more details of the methods of setting props and bars would have been given, and of the maximum distance apart at which props should be set; whilst on the contrary other members mention as a reason for adjourning the discussion that the paper was already so long as to preclude its being thoroughly discussed on merely hearing it read. In resuming the discussion, therefore, it is satisfactory to say as to the two points on which more was expected they are still open, and ample enough for distinct papers, with which perhaps the suggestors will at an early opportunity favour the Society.

The present paper now open for further discussion is mainly an historical outline written in hopes of reconciling two points—1st, the differing tests of the strength of the woods commonly used in mines, and 2nd, the difference observable in the angle at which props are set, especially where the dip of the mine is steep.

As to the Strength of the Woods, the paper quotes records for nearly four centuries showing diversity in the results of tests. In addition to those descriptions I have to-day brought for view a sample of peculiar structural growth of wood, in which the pith and first two years of growth are surrounded by a smooth surface, as though vegetation had been arrested and then succeeded by the

further growth of many years. One of the peculiarities of this specimen is that over a small knot on the interior growth the overlying rings of all the succeeding years growth are twisted. With such, and other evidences of variation of internal structure, tests of strength of different pieces of wood do not apparently admit of uniformity nearer than that obtainable from averages between the two extremes of maximum and minimum strengths. The supposition, however, that formerly the tests were made only upon small pieces of selected wood, and that latterly the tests have been upon larger pieces, is a subject upon which some decision may be arrived at.

The degree in which strength is lessened in proportion to increased length has recently been treated upon by Mr. Robert W. Dron, before the Mining Institute of Scotland (Trans. M. E., Vol. XVIII.), in which, according to the authorities quoted, it is held that length operates only against strength when the length exceeds ten times the diameter. Therefore, as the length and diameter of many pit props approximate this ratio, the conclusion arrived at by Professor Louis on this point from his experiments is practically correct.

As to the Angle at which Props should be set, especially in steep mines. Whether all should be set at a rectangle to the common axis of pressure, or sufficient of them with diverse slopes to guard against occasional pressure from other directions, it is remarkable that entire uniformity has not been arrived at after the recorded thousands of years' experience of mining. Divided opinion on this point on the part of only a few miners may be attended with consequences besides those of an occasional toppling over of a whole setting of props. The direction in which such props should be set is sometimes put as a question

in examinations, and a candidate may be placed at a serious disadvantage if his and the examiner's training have been under differing systems.

THE SUPPLY OF PITWOOD is generally treated as though it were inexhaustible. Inadequate home supply has been readily met by imports. But now warning is being given lest the serious decrease of woodland occurring in proportion to the area of all parts of the globe, with few attempts at re-planting, may bring about scarcity of timber generally. From statistics taken from returns on "Forest Devastation," furnished by Mr. R. W. Dron, in Chambers' Journal, January, 1900, it appears that the percentages of the area of woodlands are being greatly reduced, and are now only: in Europe, 31; Asia, 20; Africa, 20; Australia, 20; America, 21 (including the United States, 23; and Canada, 37). Those of the United Kingdom being: England, 4·8; Scotland, 4·5; Wales, 3·5; Ireland, 1·6. The percentages of the countries whence our chief imports of pitwood come are still large, namely: Sweden, 34; Norway, 24; Finland, 56; Russia, 37; but these areas are dwindling.

Afforesting with firs and pines might, it appears, afford even now a moderate return. Possibly, therefore, scarcity of timber may be avoided by the replanting of large areas. Even should the outcome of pit wood prove eventually unfavourable, adequate substitutes may be found in increased pack walling and steel tubes for props.

HOLLOW STEEL TUBES, with the ends closed, are now shown by Professor Louis's further experiments (Trans. M. E., Vol. XVII.) to be capable of supporting nearly twice as much weight as wooden props. His tests were made with 4-feet lenghts and varying diameters and thickness of steel. As a sample, the average of those $2\frac{3}{4}$ inches in diameter and $\frac{3}{16}$ inch steel, weighed $18\frac{1}{2}$ lbs., and the break-

ing weight was 6,563 lbs. per square inch of area. All broke by flexure, each giving ample warning.

Apparently, therefore, although waste of timber (or of anything) is to be deprecated, whatever may result from timber becoming less plentiful, props of some kind will continue available for adequate support of mines, and that apprehended scarcity of suitable material need not influence our present discussion.

I have a letter from Professor Louis which may be of interest to you. Writing on 11th inst., from the Durham College of Science, Newcastle-on-Tyne, he says:—

Dear Sir,

I am much obliged for the copy of your paper on "Pit Props and their Setting," which you were good enough to send me, and which I have read with much interest. Of course I have not attempted to reply to such criticism of my results as that of Mr. G. L. Kerr, who quotes against my figures those given by Mr. T. Box, oblivious of the fact that these figures are obtained on selected blocks of wood 1 inch cube; when pit props of such dimensions come into practical use, his arguments may be worth considering—but not till then.

The point that seems to have puzzled most people is my statement that the resistance of a vertical prop to crushing is independent of its length within the limits of practical work. This not only results clearly from my own experiments, but also follows from the mechanical theory of the subject, and has long been known; according to Hodgkinson and other authorities, length only becomes a factor when the length is greater than 30 diameters. I myself take a lower limit and consider the length unimportant when it is less than 15 diameters. Such a prop as Mr. Hall suggests in his discussion on your paper, namely, 3 inches diameter and 84 inches high is of course unknown in practice, and falls equally outside the limits of practical work and of my statements. I quite agree with him that to set such a prop in a mine would be ridiculous; surely it is equally so to apply my rule to a case so far beyond my limits. I am quite clear on the point that within the limits I have laid down the

length of a prop does not affect its strength, except, as I have indicated in my original paper, as far as it admits of the inclusion in the prop of a greater number of weak points; the larger the prop—whatever its diameter—the greater the probability of finding a weak spot in it, and the strength of a prop is merely that of its weakest part. That is why a pit prop, taken as a whole, gives such far lower results than do the small carefully selected specimens tested by Young, Box, Molesworth, etc.

It is rather remarkable how nearly Dütting's figures (five months after felling, which corresponds nearly to my average conditions,) agree with my own, both of us working on actual pit props. You will note from his paper that he also finds the strength to be independent of the length.

Of course these figures only apply to cases where the prop yields under crushing strains; the moment transvere stresses are set up, *i.e.*, when the wood acts as a beam and not as a prop, length becomes an important factor. This must occur whenever the prop deviates markedly from the vertical—probably whenever the line of pressure at the top falls outside the base of the prop.

The question of taper has never yet been settled; no one seems to know to what extent a truncated cone is stronger than a cylinder having the same area as the smaller end of the cone. I hope to investigate this question some day.

I send you herewith a paper I contributed some little time ago to the *Colliery Manager*, in which I have gone a little into the mechanical theory of timbering; this bears out one of the points raised by you, and may interest you.—(*Colliery Manager*, Dec. 15, 1899.)

Yours sincerely,

HENRY LOUIS.

Mr. DICKINSON: The letter from Professor Louis clears up some of the points that Mr. Hall brought forward at the last meeting.

Mr. HENRY HALL said he thought he had better put himself right with Professor Louis first. He did not dispute at all that his experiments were quite correct. He thought there was no doubt that the crushing stress would be the same whatever the length, over a reasonable length, so long

as the timber was of the same strength from top to bottom; but where he differed with Professor Louis was as to the utility of the crushing stress in reference to a matter of this kind. As soon as ever the crush deviated from the precise perpendicular it no longer became a crushing stress but a transverse one, and he said that it did not happen once in a thousand times that a crush came on in this perpendicular way that was suggested in mines. Therefore, so far as Professor Louis's remarks on this point went they were not, he thought, of such importance as might be supposed. Mr. Dickinson at their last meeting drew attention to two particular points in his paper which he said very few of the gentlemen who spoke after he had read the paper had referred to. One was the great variation in the amount of crushing stress required to crush timber given by the different authorities. Well, he had read Mr. Dickinson's paper through, and no doubt the results arrived at by the authorities varied very much—to the extent of fifty per cent. in some cases. He imagined the reason for that variation was that the timber experimented upon, although called by the same name, was really very different in texture. He could imagine timber that had grown slowly would be very much stronger than the same timber that had grown rapidly. He saw in the paper attention was drawn to that by the measurement of the growth of the different rings around the timber, but he did not think sufficient importance was given to that. He thought that the reason the experiments differed so much in their results was found in these considerations. Another point Mr. Dickinson drew attention to was the mode of setting. Mr. Dickinson suggested that it might be useful, say, in a wide-work face, for instance, that part of the props should be set at one angle and part at another. Well, he saw exactly what Mr. Dickinson had in his mind, and no doubt if they could hit upon the right

angle for the different sets of props, they would gain an advantage; but he did not see how they could tell from which direction the crush was going to come. Mr. Dickinson suggested the crush would come towards the dip. It would come towards the dip, no doubt, if there were not other circumstances favouring its coming in some other direction. Hence, he considered it almost impracticable to set the props at different angles in different directions, and in the end the best plan would be to set them at right angles to the dip. As a matter of fact they never were set exactly at right angles to the dip. At a meeting of the Midland Institute rather a novel suggestion was made in regard to setting props. It was that the bottom of the prop should be tapered down to about one half its width, so that when the weight came on this tapered part would buckle and bulge out, as it were, and so avoid the prop being broken in the middle. At that meeting several Colliery Managers said they had practised the suggestion, and one of them said the practice resulted in 25 per cent. of saving of timber. He did not know how they made it out, nor how they managed it, for he imagined the result would be that every prop that was tapered down in this way would be damaged to the extent of some five or six inches at any rate, and would no longer be suitable for that seam. It had been suggested by several Colliery Managers that a far better plan than tapering the props would be to fix some softer timber at the top or bottom so that when the stress came the prop would sink into the softer wood and so avoid being broken. That seemed to him a very useful suggestion.

Mr. J. Gerrard concurred with Mr. Hall that if they could, in the way suggested, prevent the breaking of the prop it would be a great improvement. He was sure that the members who were interested in this important question of timbering in mines would read again and again Mr.

Dickinson's valuable paper. He also desired to say that his experience led him to agree with Mr. Hall's observation at a previous meeting. One often found in investigating fatalities from falls of roof that it was an entire absence of props rather than their weakness which had caused or contributed to the accident.

Mr. JAMES TONGE also expressed his agreement with Mr. Hall that it would be much better if instead of tapering the props they put a piece of softer timber on the floor or against the roof, above or beneath the prop.

Mr. DICKINSON said there was a difference of opinion among colliery managers as to the setting of props. Some argued that all the props should be set at right angles, while others said they should have a slight lean up the hill; and seeing this was a question sometimes put by examiners to candidates for Managers' Certificates he had thought it well to bring the subject before the Society and the mining public so that it might be seen this was not a point which was so dogmatically settled as to be put as a question to which the answer "Yes" or "No" would perhaps affect a candidate's passing as a Colliery Manager. Another point he had in view was to reconcile, if possible, the great variations in the results of the tests. But that was not the only point. The way in which many of the results were tabulated in some of the different pocket-books was so obscure that one really had a doubt whether every person understood what he was writing about. He had tried to bring together the different names by which persons called the same thing, and to give explanations, so far as he could, so that these things might be intelligible to the rising generation. He hoped he had thrown some light on the subject—he had endeavoured to do so—and that the result would be profitable to the young.

Mr. J. H. W. LAVERICK writes as follows:—Observing that in the discussion on the above, reference was made to the Hepplewhite Tapered Prop, he would like to correct one or two misapprehensions with reference to the same. It is found from experience that the tapered prop does not "buckle" (this is what the ordinary props do), but they "fuzz" out at the bottom which is what is aimed at. As to the suitability of tapered props for a particular seam, experience alone can decide. In the case of a strong roof and a strong floor, it is found that tapering is a distinct advantage, and preserves the life of a prop very considerably. After two or three settings a tapered prop will become shortened, and a soft lid at the foot may be used with advantage. From an economical point of view it is not advisable to use a soft lid at the foot until the shortening of a prop makes it necessary, because the lid will probably be left behind in the gob.

Tapered props can be adopted to better advantage where seams of varying thickness are being worked, so that when the props become too short for one seam, they can be sent out, re-tapered, and used in another seam.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XXVI. SESSION 1899-1900.

The ORDINARY MEETING of the Members was held on Tuesday, April 10th, 1900, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. W. S. BARRETT,
In the Chair.

THE LATE MR. G. H. MORTON, F.G.S.

Before the commencement of the ordinary proceedings Mr. MARK STIRRUP asked permission of the President to refer to the loss which the Society had sustained in the recent death of one of their Honorary Members, Mr. George H. Morton, F.G.S., of Liverpool, a geologist well known for his work among the Carboniferous Limestone rocks of North Wales and the Triassic strata of Liverpool and neighbourhood.

It will be remembered that so recently as the closing meeting of the last session, Mr. Morton exhibited and explained to the members his large map of the geology of Liverpool, upon which he had been engaged for many years,

following up as opportunity offered the tracing of the limits of the Triassic beds and the faults which pervaded them.

Mr. Morton's collection of Carboniferous Limestone and other fossils was well known to geologists for its completeness, and the admirable order in which it was kept.

In conclusion Mr. Stirrup moved that a vote of sympathy and condolence with the family of Mr. Morton be passed and forwarded, as follows:—

> "That the Society has heard with great regret of the death of their respected Honorary Member, Mr. George H. Martin, F.G.S., of Liverpool, so long appreciated as an able exponent of the Geology of that City and of the Carboniferous rocks of North Wales."
>
> "Further that the Society desires to express deep sympathy and condolence with his family in their bereavement."

Mr. Joseph Dickinson seconded the motion, which was unanimously adopted.

Mr. Mark Stirrup contributed the following notes "On the Minerals Celestine and Baryto-Celestine":—

ON THE MINERALS CELESTINE AND BARYTO-CELESTINE.

By Mr. Mark Stirrup, F.G.S.

I am indebted to a friend, resident at Bristol, for the specimens of Celestine and its associated mineral Baryto-Celestine now lying on the table. They come from a new section in Rhœtic strata which has been recently exposed, a detailed report of which has been presented to the Geologists' Association of London by Mr. W. H. Wickes, the author.*

The mineral Celestine, or Sulphate of Strontium, occurs but sparingly in the British Isles, but its presence has long been known in the rocks underlying and around Bristol, where it has been extracted for commercial purposes. It occurs either crystalline or massive.

The principal source of supply is the Keuper Marls, in which the mineral is found very irregularly distributed in the shape of nodules, or oval and rounded blocks varying from a few ounces to more than a ton in weight.

The Keuper Marls sometimes rest conformably on the Keuper Sandstone, and in other sections may be seen lying upon the upturned edges of the Carboniferous Limestone.

Small crystals of Celestine often occur disseminated through the marls, but the finest specimens have been obtained from cavities in the limestone rock.

The blocks of the massive variety of mineral usually occur at the base of the marls, a circumstance which may tend to explain the mode of their deposition.

From the form and position of these blocks, it would appear that the Keuper Marls are not themselves the source of the mineral, but are merely the matrix, as it were, into which waters, containing the sulphates in solution, have

* Proc. Geol. Ass., Part 7, Vol. XVI., May, 1900.

filtered from superincumbent beds (probably Rhœtic), and afterwards slowly deposited their mineral contents, which have segregated and crystallized as shown by the specimens.

Small deposits of Celestine and Baryto-Celestine are often being exposed in the neighbourhood of Bristol and Clifton when excavating for the foundations of new buildings.

The usual companions of Celestine in the stratified rocks are gypsum and rock salt, but fine cystals of Celestine associated with sulphur are found in Sicily.

The crystals are either rhombic prisms or tabular; often long and slender; the Bristol specimens are as a rule of the tabular form.

Strontian, in Argyleshire, where the mineral was first recognised, has the honour of contributing the name of the metal Strontium, while the name Celestine has been given on account of its sky-blue colour, a feature which Bristol specimens rarely possess, they being usually white.

The composition of the sulphate of strontia is given as strontia = 56·4, sulphuric acid = 43·6 per cent.

It colours the blow pipe flame a carmine red, and is employed for producing a red colour in fireworks and other industrial purposes.

Sometimes baryta and lime are present, replacing some of the strontia, as in some of the specimens on the table.

The Baryto-Celestine examples my correspondent seems to appreciate more than the Celestine, owing doubtless to their scarcity. He writes me to the following effect:—"There is very little of this; in fact, while there are *hundreds of tons* of Celestine round Bristol, I doubt if there are the same number of *ounces* of this Baryto-Celestine, which is a *great rarity* in a mineralogical sense. Bristol is, so far as is known, the *only British locality* for Baryto-Celestine."

Mr. Norman Collie, in a paper on the Celestine and Baryto-Celestine of Clifton, in the Proceedings of the Bristol Naturalists Society, 1879, gives several analyses of these

minerals, and remarks that barium was present in considerable quantity in some of the specimens, but he failed to detect calcium, or any other substance but strontium and sulphuric acid.

In Mr. Collie's analyses of the relative proportions of the sulphate of strontium and sulphate of barium in his Clifton specimens, they were found to vary very considerably, the results of which are given in the paper referred to.

Mr. Collie says:—"From these numbers it is obvious that the Celestine of this neighbourhood is an isomorphous mixture, in varying proportions of the two sulphates, and on the supposition that it has been slowly deposited from aqueous solution, we should expect this to be the case, the amount of each sulphate varying with the amount of sulphate in solution. Again, as sulphate of strontium is much more soluble than sulphate of barium, we should expect the former to preponderate in a mixture separating from solution, and that is exactly what we observe in the case of Bristol Celestine.

The occurance of Baryto-Celestine, that is to say, of a mineral containing such a large proportion of sulphate of barium is remarkable, considering the fact that so much sulphate of strontium occurs in the neighbourhood; and it can only be accounted for by assuming that the bed from which the the sulphates were originally dissolved out, contained a very large proportion of sulphate of barium as compared with sulphate of strontium. One would scarcely have expected specimens to vary so widely in composition where they occur so close to each other as those which I examined, and I think that this difference of composition is of much interest."

Mr. Dickinson asked what was the commercial purpose for which celestine was used.

Mr. Stirrup said it was used for sugar refining, he thought, but it was also used by pyrotechnists for producing a red flame.

Mr. G. C. GREENWELL wrote as follows :—

"I am sorry that my present state of health will not allow me to attend the meeting of the Manchester Geological Society on Tuesday.

"Celestine (sulphate strontia) has been found in large quantities in Gloucestershire at Yate and elsewhere. I have seen it at Yate where it is found in a somewhat irregular stratum or deposit in new red sandstone, where it lies near the surface as a bed one or two feet in thickness. I brought away several specimens, some crystalline in good crystals and some coarsely saccharine. It was sold at Yate by truck load at Yate Station for about 10s. per ton, a royalty of 2s. 6d. per ton being paid to the then Rector of the Parish for that got from the Glebe. I gave my best specimens to the Natural History Society of Newcastle-upon-Tyne."

Mr. DICKINSON remarked that a royalty of 25 per cent. on the selling value of a mineral seemed very high.

Mr. LINDSEY said that in the blue book, dealing with Mines and Quarries for 1898, the total amount of celestine raised was returned at over 13,000 tons, against 15,000 tons for the preceding year, so that this was a larger industry than was generally supposed.

The PRESIDENT remarked that he had met with specimens of the Celestine or Baryto-Celestine in a mine in the south of Ireland. The mineral there was much stained, and to get rid of the stains acid was used. Freed from stains the article had a much higher selling value. He did not remember whether there was any blue stain in the mineral. He moved that the thanks of the meeting be given to Mr. Stirrup for his contribution.

Mr. DICKINSON, in seconding the resolution mentioned that there were several barytes mines in Ireland in which the mineral had been found.

The resolution was passed.

Mr. Joseph Dickinson contributed the following notes on the late Mr. John Nixon and Sir George Elliott, Bart.:—

THE LATE MR. JOHN NIXON AND SIR GEORGE ELLIOTT, BART.

Brief Notes by JOSEPH DICKINSON, F.G.S.

We are justly proud of the Manchester Geological Society. Established in 1838, and yet in the vigour of youth. A generation ago we were aroused by something like threatened legal proceedings by the British Museum for omitting to send them a copy of our printed transactions. Now it seems they have a plethora of published literature for which they cannot find room, and are moving the House of Lords to deliver them from the dilemma. Whether our honorary secretaries foreseeing this coming change and wishing to shorten some of our ponderous papers, or perhaps desiring something more lightsome, have announced for this meeting "Short communications will be gladly received." It can scarcely be the want of papers or they would have made the want more known. Be the cause what it may, I have pleasure in responding with a few hasty notes on two deceased colliery owners, Mr. John Nixon and Sir George Elliott, who were friends of mine from my boyhood.

Mr. JOHN NIXON, the well-known South Wales Steam Coal Colliery Owner, has, I see by a recent review in the *Manchester Guardian*, been recently perpetuated in a Memoir of some 245 pages by Mr. James Edward Vincent (John Murray) which I hope to see. The working of Welsh Steam Coal did not originate with him. Before he began, the Dowlais Company, where I was engaged between 7 and 8 years, had long worked and used 1,500 tons a day in making iron, leaving the surrounding hills and valleys almost free from smoke, others did likewise. What Mr. Nixon did was developing the export of the coal, from what became

known as "Sea Coal Collieries," to which South Wales now owes much of its prosperity.

As in some of the tales in weekly periodicals, he is represented as making his way from the position of colliery overman at 3s. 6d. a day. When I first knew him he was about finishing his pupilage in a colliery as I was entering my pupilage with a mining and civil engineer. He was my senior by a few years. Work then generally began earlier than now. I was 14½ years old. The idea was not to leave entering on the duty of life until a person became too big and too old to ask questions or be supposed to know what he was ignorant of, but to supplement wanted learning by evening tuition, although office hours did not terminate until 8 o'clock, Saturdays included.

He lived near Winlation, 5 miles West of Gateshead-on-Tyne, in County Durham. His family were substantial residents and visited with my family. He had four sisters, all good looking. The elder two were each married to colliery viewers both named Gray. The youngest afterwards married similarly; but the third one, I think remained unwon, but possibly it may have been otherwise as I left Northumberland for South Wales in 1840, and I have since been an absentee except as a visitor. When I first made his acquaintance he was at Garesfield colliery belonging to Lord Bute, where his brother-in-law Mr. John Gray was the viewer. He might in gaining experience be an overman, as stated, earning 3s. 6d. a day, but was never likely to remain in that position.

Soon afterwards he was engaged in opening a colliery in France. During this an accident occurred, which may remind many miners of like experience in their own life. In sinking the shafts air-pipes were used, the fixing of them being by strong iron holdfasts; and in descending the end of one of these holdfasts caught him by the seat of his

trousers and left him hanging as the hoppet went on downwards. His natural doubts lest the cloth or the holdfast might fail may easily be imagined. Fortunately both held good until he was rescued.

Another of his early works was the making of a report on Lord Bute's leased mineral property near Merthyr Tydvil. This I had an opportunity of reading when at Dowlais. It alluded to the waste of coal left in pillars between the stalls, which was then common in the thick seams with bad roofs, but has now been rectified by longwall. The time for change had not then come. Miners generally liked to have their own place.

He afterwards began his career as colliery owner, commencing with a shallow colliery at Hafod, in the Aberdare Valley, which I had opportunities of visiting. Later on he opened on the dip at Navigation. At the latter he applied a very large horizontal air pump for ventilation, on the Mahoux principle, and it is still called the Nixon ventilator. He always had a scientific bent. One question he propounded when on a visit to me was:—"Is it steam or water when without any escape the inside of a strong globe is filled with water and the globe heated to a high temperature?" I last saw him in a Committee Room of the House of Commons. He was then tall, thin, and wiry, as before.

Sir George Elliot, Bart., really did begin life about eight years of age, as a door boy or trapper in a colliery. His father, however, before him had made his way to be a colliery official and lived in a double house at the end of Shiney Row, at Pensher, in County Durham, which may have removed some of the obstacles to the son's advancement. I have stayed there, and when he became a fireman I have gone the round of the workings with him in early morning to see the places free from gas before the colliers entered.

He had too much energy to remain down. The first main

conclusion he arrived at was to obtain scientific knowledge; and rather late in life (he being my senior in age) he came to Mr. Thomas Sopwith's, with whom I was a pupil, and he was with us assisting on several important engineering works, including setting out the Great North of England Railway between Newcastle-on-Tyne and York, of which Mr. Thomas Storey was the engineer.

Until middle life he was proud of and claimed extra practical knowledge from his very early beginning in the pit. I once at an inquest thought I had offended him by rejoining that he would have been better at school. He, however, laughingly related the incident to my family.

As is well known he became a large colliery owner in Durham, North Staffordshire, North Wales, and South Wales, having his offices in George Street, Westminster.

Like many north country miners he was fond of anecdotes; and it is said that he was the life of the government party when sailing out to see how the then newly acquired island of Cyprus could be utilized. I could say more, but the call for short communications is before me.

The PRESIDENT said the Society was very much indebted to Mr. Dickinson for the paper. It was desirable, he thought, that occasionally they should turn aside from the more serious subjects of study and be led to think of men who had been engaged in the same branches of work as they themselves were. In this case Mr. Dickinson had added to the interest in his theme by giving some of his own recollections of the men referred to. He had much pleasure in moving that the thanks of the meeting be accorded to Mr. Dickinson.

Mr. W. SAINT seconded the proposal which was passed.

The following communication on the Salford Earthquake was sent by Mr. C. E. DE RANCE, Assoc.Inst.C.E., F.G.S.:—

THE SALFORD EARTHQUAKE.

By C. E. De Rance, Assoc.Inst.C.E., F.G.S.

The current number of the Geological Magazine (No. 429), contains an interesting communication from Dr. Charles Davison, F.G.S., on "Minor British Earthquakes in 1893-99," and they are of special interest at the present moment, in regard to the Earth-wave which traversed Salford, on Saturday morning, the 7th of April. Dr. Davison has taken up, in his researches into British Earthquakes, the practical lines, learnt by the long experience of Professor Milne, in Japan, and it behoves every geological worker to assist him to their utmost; and the Salford Earthquake, in this respect is of great interest in regard to the Salford Pendleton fault.

Dr. Davison states "that the number of earthquakes described is 19, and with few exceptions, I have not been able to correlate them with known faults. It should not be inferred from this, that the shocks owe their origin to some other cause than fault slipping; for in nearly every case, the epicentral region, is one in which it is difficult to detect faults. It is possible, indeed, that the careful study of an earthquake may form a useful supplement to the methods which are at the disposal of the field geologists."

Dr. Davison adds, as regards "map symbols":—"In a weak earthquake every place of observation can generally be marked on the map; and without making use of a wide range of symbols, it is convenient to employ signs to represent the perception of the shock and sound." He uses a "square" for points where the shock was felt; a "triangle" when it is doubtful whether it was experienced;

a "circle" that no shock was felt, a figure entirely filled in that shock and sound were experienced, one half-filled in that perception of sound was doubtful, and one not filled in at all that no sound was heard.

The Earthwave at Pendleton and Seedley, though fortunately exceedingly slight, doing no further damage apparently than bringing down a coping stone of St. James's Church, Church Grove, is remarkable for the amount of noise experienced both on the surface at Gerald Road, Pendleton, and underground at Pendleton Colliery, at a depth of 3,500 feet, and in this corresponded to the earthquakes I have experienced at Preston, Lancashire, and Stoke-upon-Trent as regards the surface, which I have respectively described in the columns of *The Times*, *Nature*, and the Journal of the "North Staffordshire Field Naturalists." I venture to suggest a small Committee of Enquiry into the matter, should be formed.

Mr. STIRRUP said the article On some British Earthquakes, by Dr. Davison, in the "Geological Magazine" for this month, which Mr. De Rance had probably read, contained all the details which he (Mr. Stirrup) had sent to Dr. Davison relative to the earth-shock in this neighbourhood on February 27th, 1899. The disturbance at Pendleton on Saturday morning was not a true earthquake; it was an earth movement due, most likely, to fault slips; or it might be there was some little sinking going on in those lately-worked coal districts. He had intended, at this meeting, to ask any of the members who were engaged in coal mining operations in the Pendleton neighbourhood if they had any experience of the shaking last Saturday. All he knew was from what appeared in the newspapers. Some persons, he understood, felt the motion while in bed.

Mr. DICKINSON: I may say that at 17 minutes past one, as I looked at the clock, on Saturday morning last, I both heard and felt very distinctly an earth-shock. The sound was as though the mortar of the walls of the house were being crushed, and dribbles of lime came down my bedroom chimney. The shock woke and frightened every member of my household except one, who is not very quick at hearing. They were very much alarmed. From what I hear of what took place in the surrounding neighbourhood, the general impression appears to be that it was not an earthquake, but that it was something connected with the hands of man. The raising of so much dust in the collieries, as stated in the newspapers, shows it was more likely to be due to something connected with the workings. There is this peculiarity about it: we have an immense bed of sand overlying the coalfield in the vicinity, and the drain of the water from this sand may have something to do with our having such unpleasant experiences as those which we have passed through on previous occasions and on Saturday morning last. I had a letter from a neighbour asking me to call and see him next day to see the cracks in his house. I have said that the first main shock on Saturday morning was at 17 minutes past one, but a smaller one—a pretty loud thud—followed, and another small one within half an hour I lay awake for some time, fearing that the gas and water pipes might have been torn asunder. The shock was enough to do that.

Mr. HOLROYD said the shock so strained the lead piping in the cellar of his house that a jet of water was sent up against the ceiling and the pipe had to be repaired on the Saturday afternoon, so that it was quite possible that an earth-slip of that character might have very important effects on water and gas piping. Occurring as it did in the

early morning an escape of gas might be fraught with serious consequences.

Mr. TONGE said that about three years ago, when there had been an earth-shock, he made a number of enquiries at the instance of Mr. Stirrup, from persons who were in the mines at the Hulton Collieries at the time of the shock, and also from persons living near the collieries who were at the same time on the surface. He was somewhat surprised to find that no one *underground* at the time had felt it, but all others who happened to be awake had.

Mr. STIRRUP appealed to members to bring before the Society at the time of the occurrence all the information at their command in regard to these earth-shocks, a summary of which would be afterwards sent on to Dr. Davison who is engaged in collecting evidence on British earthquakes.

Professor EDWARD HULL, F.R.S., &c., contributed the following note "On the Sub-Oceanic Valley of the River Congo":—

NOTE ON THE SUB-OCEANIC VALLEY OF THE RIVER CONGO.

By Professor Edward Hull, F.R.S., &c.

As a sequel to my address at Owens College "on the Sub-Oceanic Valleys of Western Europe," I enclose for the inspection of Members of the Society a proof copy of the Submerged Valley of the River Congo, which I have worked out by the aid of the Admiralty Charts. It is intended to illustrate a paper about to be published by the Victoria Institute, and of course cannot be made use of beyond this channel of publication.

I may mention that the first delineation of the channel was made by Mr. Stallibras, Telegraphic Engineer, whose very accurate map was put in my hands by Professor Boyd Dawkins, F.R.S., when I was with him in Manchester on the occasion above referred to. Mr. Stallibras carried the channel as far down as the 1,000 fathom contour, but the Admiralty Chart has enabled me to extend the mouth of the channel as far as the 1,200 fathom contour, where it opens out on the abyssal floor. It is a remarkable coincidence that this is the very depth of the mouths of most of the submerged river-valleys of Western Europe. Perhaps Mr. Mark Stirrup, if present, would hand the little map round.

Mr. Greenwood, in commenting upon Professor Hull's paper, on "The Ancient Coast Line of Western Europe," and his suggestions that the extended land area may have been the cause of the ice age, expressed his opinion that it was reasonable to take the opposite view. Assuming the correctness of Sir Robert Ball's theory, that "the ice age was

caused by extra terrestrial influences," would not the volume of the ocean have been reduced by so much water as was piled upon land in the form of ice and snow, and would not the land area have been extended correspondingly.

Mr. STIRRUP remarked that if they were drawn into a discussion on the many speculations with regard to the cause of the ice age it will not be a short but rather a long communication they would have. With regard to Professor Hull's opinion, as to the cause of the ice age, he thought Mr. Greenwood had grasped quite well his view, which was that the land area or the mountainous regions of the globe rose at one time to a greater elevation than now, causing increased cold and a larger precipitation of snow. The changes thus brought about in the distribution of land and sea, were sufficient it was thought, to account for the phenomena of the Ice Age. With regard to the theory of Professor Ball he for one did not place much confidence in it, as it was founded on astronomical assumptions and, moreover, did not harmonize with geological data.

ACETYLENE LAMPS FOR MINERS.

Mr. HARRISON, H.M. Inspector of Mines, called attention to a lamp lighted with acetylene, and specially designed for the use of miners. He pointed out that the lamp was intended only for places where an open lamp was permissible, and in such cases its chief advantage was in the great brilliancy of the light which it gave. With its aid one could see in the mine as well at 35 yards distance as at seven yards with ordinary lamps.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVIII. VOL. XXVI. SESSION 1899-1900.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, May 11th, 1900, in the Mining School, Wigan.

The President, Mr. W. S. BARRETT,
in the Chair.

Mr. BARRETT said there is a very important meeting of the coal trade in Wigan at half-past Three, which will prevent many from coming here to listen to the interesting papers which we shall have this afternoon. I shall have to leave at half-past Three and to save interruption I will ask Mr. Ridyard to take the Chair.

Mr. RIDYARD accordingly took the Chair.

NEW MEMBER.

Mr. HENRY JOBSON, Mining Student, Bank Hall Colliery, Burnley, was balloted for and unanimously elected an Ordinary Member of the Society.

The following paper on "A New Method of Sinking Pits by Machinery," was read by Mr. RICHARD SUTCLIFFE, M.E. :—

ON A NEW METHOD OF SINKING PITS BY MACHINERY.

By Mr. Richard Sutcliffe, M.E.

It may seem strange but, nevertheless, it is a fact that we sink pits to-day very much as our ancestors did in the years long past, while we have improved upon nearly all the other several branches of mining. Of course they had not the high explosives of our time, and some other improvements of detail have been devised without altering the principle, which now, as then, is laborious, slow, and costly. To-day, as then, we use the hammer, drill, and wedge as the chief implements in the process, and with them we achieve results which our forefathers would not have dreamt of. With our high explosives we blow and rend the solid rock, often pulverising it into sand, and frequently also shatter the pit sides to a greater extent than we desire.

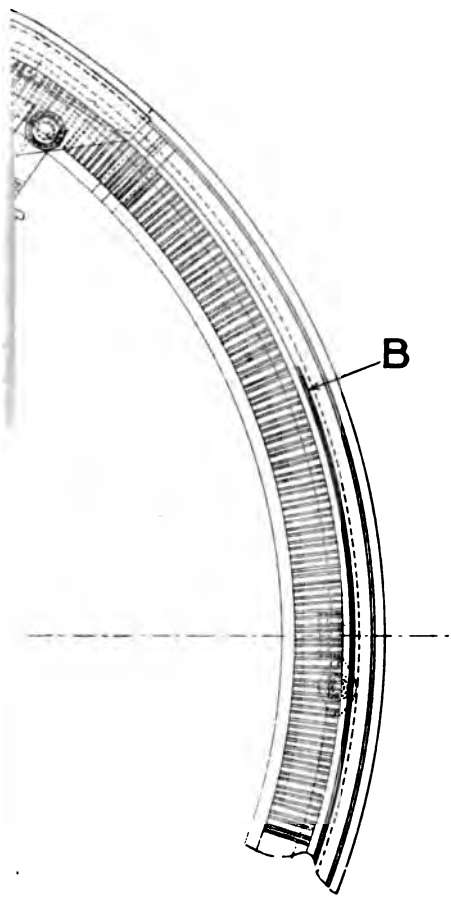
This work is sometimes done under great difficulties, caused by the flow of water, amounting in some cases to upwards of 3,000 gallons per minute, or 180,000 gallons per hour.

The pumping of this large quantity of water is rendered much more difficult by the sand and grit produced through pulverising the stone by enormous charges of blasting material.

This sand, as all sinkers well know, plays sad havoc with the best of pumps, and consequently endeavour is made to keep the water out of the pit bottom by inserting a cistern, or making a lodgement, as the case may be, below the feeders in the pit as soon as it is sunk deep enough to allow it; and the water is pumped from such cistern or lodgement free of the grit made on the pit bottom. This, however, is only a

Trans. Man. Geo. Soc, Part XVIII. Vol. XXVI.
to illustrate Mr. Richard Sutcliffe's paper.

Plate I.



ACHINE.

partial remedy, because in the best constructed machinery stoppages will occur, and when the pump connected with the cistern or lodgement stops for repairs, or through any other cause, the water finds its way to the bottom and has to be got cut again somehow. The water also being made in the bottom generally has to be delivered into the cistern to be taken hold of by the higher pump, which, in this way, still has to deal with some of the sand. When the feeders of water become large and numerous the pumps necessary to deal with the water also become numerous, and soon tax the capacity of the largest pits, contracting the space that should be reserved for the passage of the sinking trunk. This space should be at all times large, but especially so when guides or conductors are not used, yet it is surprising what a small proportion of the pit can be retained in some cases for this all important purpose. This contraction of the space in its turn impedes the expeditious execution of work of every kind in the shaft, hence the time occupied in sinking through a short distance under such circumstances is often very considerable, and the work very costly; causing much anxiety and discouragement to all concerned.

It is satisfactory to note that during recent years the mechanical engineer has done much to improve the machinery used in the sinking of pits, including several useful pumps by different makers, while the chemist has given us some exceedingly useful explosives, which are unaffected by water, and consequently expedite sinking very much through water bearing ground.

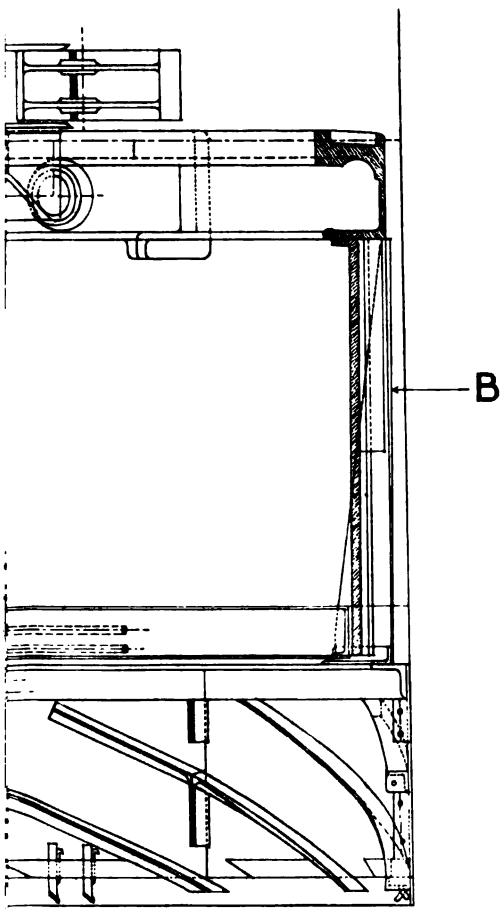
The Kind-Chaudron machine has been found useful in extreme cases, but it does not seem to have found much favour in sinking through ground producing less than 4,000 gallons of water per minute, or say 200,000 gallons per per hour. Perhaps the length of time occupied in sinking at the few places in this country where this system was

adopted told against it; and the pits now sinking, being of a considerably larger diameter necessary to admit of the output, would require very large machines to bore them, and in addition would require much longer time to sink by this system than the smaller ones formerly sunk by it. To sink an 18 or 20ft. pit would, I believe, require three or four sets of machines, with as many sets of operations to bring the pit up to the required size.

On a former occasion I had the privilege of bringing before your notice the drawings and description of a machine designed and patented by me to expedite the sinking of pits by cutting a circular grove or channel all around the pit bottom, and so separating the material to be excavated from the pit sides in advance of the sinking. Since then I have had a machine made to sink a pit 20ft. diameter, or 18ft. finished within the walling, and I have found it competent to do all I then claimed for it. It was operated by compressed air, and it worked most steadily and satisfactorily after the cutters or chisels were made strong enough to stand the cank and ironstone nodules. When the machine was first started it cut a groove 6in. deep and 6in. wide all round the pit bottom in an hour. When, however, we got into ironstone we found that the cutters should be strengthened. When this was done there was no difficulty in cutting from 6 to 12in. deep per hour, the machine making one revolution per minute in the pit bottom. In ordinary bind one set of cutters or chisels sinks several yards without being changed. By this means the pit sides are left smooth, firm, truly circular, and vertical, while the strata in the bottom is left free to be lifted, by explosives where strong, or by the pick in ordinary ground. Any holes necessary for blowing it were put in by hand drilling machines. These drilling machines were attached to a wrought-iron tube let down from the stationary frame of the sinking machine, which is 10 to 13ft

Trans. Man. Geo. Soc., Part XVIII. Vol. XXXI
to illustrate Mr. Richard Sutcliffe's paper.

Plate II.



MACHINE.

above the floor of the pit. The holes were all sloped outwards from the centre of the pit towards the circular groove or channel, and three to four holes were sufficient to break up the bottom.

The sinking with this machine commenced at the bottom of the tubbing, about 100 yards from the surface, in very hard "trunk bind" mixed with ironstone, but without partings, for a depth of nine or ten yards. At the bottom of this "trunk bind" a bed of cank about 4ft. thick was found, and underneath the cank ordinary bind set in, with a 3ft. seam of coal below it. The coal rested on a bed of fireclay, under which lay a bed of ironstone boulders resting on ordinary bind.

It will be seen from this that the sinking by this machine was through fairly representative strata, and the dip was 3 to 4in. to the yard, so that when the ironstone nodules were being cut on one side of the pit, fireclay was being cut on the other or opposite side. This fact removed the doubts of some who thought that the cutting barrel would follow down the soft side, and so jamb in the working. It however made no difference to the working of the machine.

The chief parts composing this machine (*see Plates I., II. and III.*) are :—

(A) The cutting barrel carrying chisels on its under edge.

(B) Four arms fixed on the top of the cutting barrel, and carrying slide blocks to work in guides, and cylinders for four hydraulics.

(C) An annular rack casting in four parts, and of channel section, having cogs on the upper surface of the top flange, and a plain flange on the bottom.

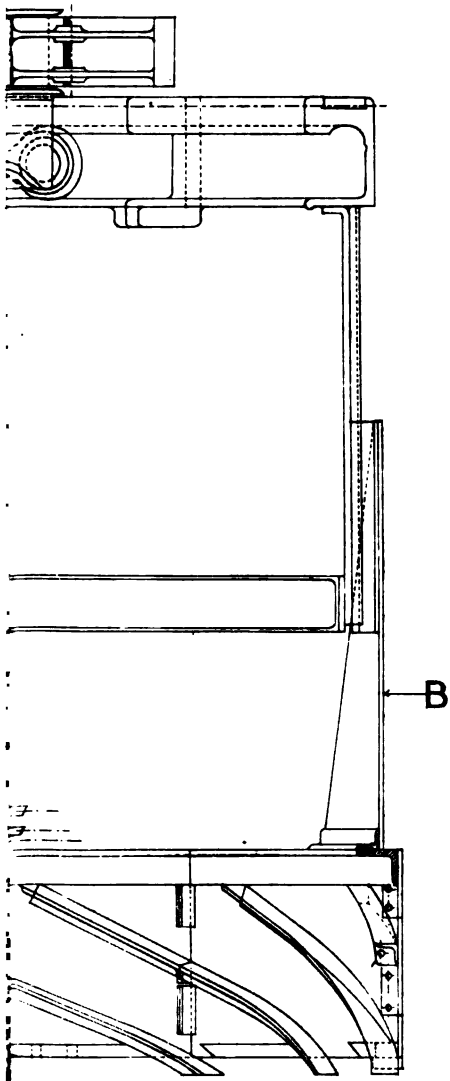
(D) A framework composed of double channel section steel girders, on which the motor and driving gear are fixed, and beneath which the horizontally rotating parts are suspended, bearing on four vertical carrying rollers.

(E) Two vertical engines used for operating the machine

The cutting barrel **A** is 19ft. 10in. in diameter, 3ft. high, and is composed of eight segments made of rolled steel plates half an inch thick. Each segment is strengthened by a 6-inch angle steel throughout its entire length, fastened on the internal side of the upper edge, and also by diagonal or sloping ribs of 4-inch angle steel. These ribs are extended below the bottom of the cutting barrel to scoop up the debris out of the channel as it is cut by the chisels, and they are also useful for turning up large stones adjoining the channel. Two pieces of iron, each 2ft. long, and 3in. square, are rivetted on the inside at the bottom edge of each segment, and each of these pieces contains two holes 1½in. square to hold the chisels or cutting tools, thirty-two of which make a set. Each chisel is fastened by two wedges, one at the front and one on the inner side. These cutters, however, can be securely held in several ways—say by clamping them to the shell or to supporting brackets which would obviate passing them through the holes as at present. All the holes to take the tools are made in the centre of the 3-in. pieces just referred to, but the cutters or tools are of five different patterns, in order to make five separate grooves or cuts within the 6-in. channel to be cut around the bottom. The small ridges dividing these small grooves break off as they are made. The middle chisel is carried straight down in order to make a central groove deeper than any of the others, but it is bent forward near the edge so as to give it a cutting instead of a scraping action. The two intermediate chisels are bent, one to the right and the other to the left, sufficiently to make two grooves midway between the central and outer ones, and the two outer cutters are bent in like manner, so as to bring the total width of the channel up to say 6in., making a clearance of 1in. between the pit sides and the cutting barrel.

Trans. Man. Geo. Soc, Part. XVIII. Vol. XXVI.
to illustrate Mr. Richard Sutcliffe's paper.

Plate III.



MACHINE.

ep.

The arms **B** are also made of ½-in. rolled steel plates. They are 7½ft. wide at the bottom, tapering off to 2ft. 3in. wide at the top. They are 6ft. high, and they have a segment of 3-in. angle steel rivetted all the way along the bottom on the inner side, for the purpose of bolting them to the cutting barrel. The four arms are placed over four opposite or alternate joints of the cutting barrel and are firmly secured there by means of bolts passing through the 6-in. angle steel of the cutting barrel and the 3-in. angle steel of the arms, giving 3ft. 9in. of lap on each segment of the former. The inner edges of both the 6-in. and 3-in. angles are made to correspond, and this gives an extra clearance of 3in., making the total clearance between the pit sides and the arms 4in. Each of these arms carries a sliding block 3ft. long, truly planed and fitted, to work in a guide which is secured to the bottom flange of the annular rack **C**, and they also carry the hydraulic cyclinders, one on each arm, which work in conjunction with the slides, and are used either to draw in or extend the cutting barrel—that is, when the cutting barrel has cut the channel and slid downwards it can be drawn up again by these hydraulics, or, when the channel has been cut a yard deep, the weight of the upper portion of the machine including the stationary framework, together with the motor and driving gear, and the annular rack, can be lifted off the walling chains by them and lowered down to the cutting barrel to commence another cut. The feed of the cutting barrel can be also regulated by them. The four guides attached to the under flange of the annular rack work on the slide blocks attached to the four arms, and are 6ft. in length. The 3ft. slide blocks are secured to the upper part of the arms and are in the upper half of the guides when starting a fresh cut, but when the cut is a yard deep, the cutting barrel and arms having slid down that distance, the slide blocks are at

the lower end of the guides, as the latter remain in the same horizontal plane while the cut is being made, and have to be lowered with the framework before commencing another cut of 3ft.

The lowering of the upper portion is done in the course of a few minutes by the use of hydraulics in the absence of a capstan. They are double acting and are operated by a hand pump which is fixed on one of the arms. The piston rods of the hydraulics are bolted to the bottom flange of the annular rack beside the guides and near the middle of each segment. The guides are strengthened by diagonal stays to prevent them yielding under the strain of work in carrying the cutting barrel round as the annular rack is rotated. In addition to rotating the cutting barrel these guides, by keeping the arms vertical, keep the cutting barrel horizontal and enable it to cut hard material at one side of the pit even if there is no material at the other side.

The annular rack C, when the machine is working, is supported on four carrying rollers which work in a rounded groove on the under side of the top flange. On the upper side of the same flange is the annular rack or ring of cogs in which the small driving wheel or pinion works to rotate the horizontally revolving parts of the machine. The carrying rollers work within the channel between the top and bottom flanges of the annular rack and carry the whole of the horizontally rotating portion of the machine.

Above the annular rack a framework D of steel is made in the shape of the letter X. The girders, three in number, are 6in. wide and 14in. deep, one being 18ft. long and two 9ft. each. The latter are joined together, one on each side of the long one, by plates on the top and bottom flanges. In the two smaller triangular spaces cross girders of angle steel are bolted to the lower flanges of the main girders, to carry the motor and driving gear. To the same flanges, near to the

four outer ends of the main girders, are fixed four brackets, projecting downwards, in which are inserted strong pins to act as journals for the four carrying rollers. In order to lessen friction two horizontal rollers are fixed on the incoming sides of two of the brackets just mentioned to work against the inner edge of the top flange of the annular rack. These horizontal rollers counteract any strain caused by the pull of the driving wheel in operating the machine. On the extreme ends of the main girders are placed four shoes which slide backward and forward several inches. They stride the web of the girders between the flanges, coming between them and the pit side. On the sides, near the ends of the girders, four corresponding brackets are placed to take powerful nuts with their screws. The heads of these screws are fastened, by pins passing through them, to the shoes. The nuts, which are placed in recesses in the brackets, are fitted with ratchets and strong levers to work them, and by this means the shoes can be pressed against the sides of the pit by enormous pressure; thus firmly fixing the frame between the pit sides and insuring the perfect steadiness of the machinery in work. These shoes are withdrawn from the sides by a couple of turns of two of the nuts every time the framework has to be lowered. Four lugs are attached to the top flanges of the girders to connect them with the suspending chains, and four right and left handed screws are inserted to adjust the lengths of the chains in order to secure the levelness of the framework. By seeing that the frame is kept level the verticality of the pit is secured, and the sheet-iron flooring of the small triangular spaces containing the driving gear affords shelter to the men in case of anything falling down the pit.

The motors E are two inverted vertical cylinders, 10in. diameter by 10in. stroke. One cylinder, or a single engine, is placed on either side of the machine. By placing the

motors on opposite sides of the machine friction is reduced to a minimum, but with small sized machines this would not be necessary.

In using this machine, if the pit were being sunk with only one rope, the trunk would pass up and down through one of the larger openings in the frame work, and the other large opening could be covered over if desired; or, in case of a heavily watered pit, the pumps could be placed in one of these openings. In order to admit of the trunk passing through one of these openings, the rope should be 4ft. away from the centre of the pit.

When putting this machine into a pit, the shaft should be sunk four or five yards below the stone head, or below the last walling crib, as the case might be, in the usual way, seeing that it is carried down that distance the full size of 20ft. As soon as this is done, the first segment of the cutting barrel may be lowered by the winding rope, and placed against the side of the pit on packing timber, say one foot high. While the men on the bottom are placing the first segment into place, a second segment may be sent down, care being taken on the surface to see that the proper segments are lowered each time in their turn, so that the men below can be bolting them together as they receive them. When the cutting barrel is completed by the eight segments being bolted together, the arms are lowered in like manner, one at a time, and bolted securely in their respective places. Next the four guides are lowered and put on to the slide blocks, which are rivetted on the arms. The tops of the guides are held level with the tops of the arms. The four segments forming the annular rack are next placed one after another on top of the guides and arms, and firmly bolted to the former, seeing that each segment is in its own guide, and each guide on its own sliding block. The segments are bolted to the webs forming the tops of the

guides as they come down, but they cannot be firmly bolted together until the whole four are in their places, because they will have to be sprung back a little to get the last one into its place. When this is done the four joints are quickly made. The diagonal stays are either sent down fastened in their places on the guides, or sent down and put on either before or after the annular rack is in its place. They are bolted to the guides near the lower ends, and to the back of the annular ring. In like manner the hydraulics may be either sent down attached to the arms, or they can be put in afterwards. They are generally left bolted to the arms and sent down with them. The long girder is the next part sent down, and placed across the pit, with its two ends resting on the annular rack. If the winding engine is strong enough, the two shoes, two under brackets to support the carrying rollers, and the two side brackets containing the nuts and screws, may all be bolted to this long girder on the surface and lowered along with it, the whole weighing between two and three tons. In any case, one of each of these belonging to the outer ends of the two short girders can be fixed on at the surface and sent down with them. As soon as the plates joining these short girders are bolted on, the cross girders, with the pedestals to carry the shafting of the driving wheels and engines, are lowered and bolted in their places, and the two spur wheels and their shafts are next placed, to be followed by the two small crank shafts and flywheels. The two small cylinders, each bolted to four vertical wrought-iron standards, are quickly lowered and bolted in position on the cross girders. They are connected together by a wrought-iron pipe, in order that both cylinders receive the air or steam at the same time by a valve or tap common to both. The hydraulics are coupled or connected by two rings of $\frac{3}{4}$-inch hydraulic piping, going all around the top of the cutting barrel, and common to all the

hydraulics and with the pump and its cistern. These hydraulics are operated by a hand pump, and, by turning the pressure on the proper side of the pistons, by opening the inlet tap for such sides, and opening the outlet tap for the opposite sides, they act in the required direction.

The whole machine is next suspended either on the capstan rope or walling chains, and the cutters or chisels inserted and firmly wedged; the framework set level; the plummet let down, and the cutting barrel brought into its exact position (9ft. 11in. all around from the centre line), by means of the screws and shoes which are on the ends of the main girders pressing against the pit side, and the shoes forced firmly against the sides so as to form a firm base for operating from. Then the machine is ready to start work.

There may be a little difficulty in cutting the first four yards if the material is very hard, because it is somewhat difficult to pack between the shattered sides found in an ordinary sinking pit and the shoes of the machines, but as soon as the framing gets within the walls left by the machine this difficulty disappears.

In taking the machine out of the pit after completing the sinking to the required depth, the last parts put in are the first to come out, and so on until the last segment of the cutting barrel is removed.

All the bolts used are of the largest size possible for the material employed, in order to lessen the number required in erecting the machine. In designing it I aimed at strength, simplicity, and fewness of parts, and I believe I succeeded.

I am firmly convinced that if the capabilities of machines like this were properly known, hand sinking would quickly become what it should be, a thing of the past.

Seeing that the strata to be sunk through is placed in horizontal or slightly inclined layers, bed upon bed, to be so

easily removed when detached from the surrounding strata, I look upon the present mode of sinking pits as time, energy, and money comparatively wasted.

I had intended to invite the members of this Society, as well as several other members of the mining profession, to see the machine in operation, that they might judge of its merits for themselves, and I still hope for an opportunity to do so, but unfortunately the pit in which I had it (Ryland's Main, near Barnsley), had to be suddenly stopped after sinking about 30 yards with the machine. I have, however, no hesitation in saying that when men are organised to work with machines like this, the sinking of pits will be accomplished in half the time now required for the purpose, while the saving in cost of timber and material will be in like proportion, and the quality of the work simply unattainable by hand sinking.

The motive power may be compressed air (and this can be utilised to air the men and cool the shaft), electricity, steam, gas, or oil—compressed air, of course, is always preferable for use in pits, because its presence is always a source of safety, and by turning the exhaust downwards, the pit bottom is kept quite cool.

As before stated the work of this machine is to plane out a groove or channel all around the pit bottom, cutting out the exact space required for the pit shaft and its protecting lining, as a first operation, leaving the sides uninjured by explosives, and perfectly plumb and circular. By its use the walling material can be placed against the sides without the aid of side lines, plummets, or templates, and the usual backing of cinders or other material can be dispensed with. The strata being liberated all around, less than one-fourth of the explosives now used will be sufficient to break up the pit bottom, and the danger and the expense connected with the use of the other three-fourths will be obviated. The

number of hands required in the pit can be reduced, while the trunk can be constantly employed raising the debris.

It is very evident that if such a machine could be used in a heavily watered sinking pit the saving would be immense, because as pits are at present sunk, nothing can be done in the shape of sinking until the bottom is unwatered, and then the first operation is with hammer and drill to put in a set of holes, unless there happen to be left some loose stone on the bottom from the last round of shots. One of these holes may be fired in the centre of the pit, and each of the others fired towards it, blowing the arched stone always inward. As a consequence it takes from 15 to 20 holes to be drilled and fired to sink a single yard, while with the groove cut around the pit the stone would be blown outwards, and if it were at all stratified four shots would suffice to sink the yard.

These four holes could be bored by as many hand drilling or power drilling machines in a few minutes, and the annular groove might be cut under several feet of water.

In all pits 18 or 20ft. in diameter there will be quite ample room on the bottom, when using this machine, for two large sinking pumps capable of raising say one hundred thousand (100,000) gallons of water per hour.

Apart altogether from the experience gained in the sinking at Ryland's Main Colliery, it only requires some study to see that sinking by this means is quite feasible when we remember that stone is continually being grooved and cut all over the country by machinery, the greatest difference being that the stone on surface is brought to the machine, while in sinking we take the machine to the stone. Many persons who were doubters until they saw it in operation, were quickly convinced when they saw it at work in the pit, and frankly admitted its applicability to its work and its steadiness in operation. The machine is simple both in principle and

construction, is easily started, stopped, or reversed. It is rigid and strong in build and material, and weighs nearly 25 tons. The heaviest single piece, however, weighs only 35 cwt. It is quickly put together or taken to pieces on the pit bottom, because it is composed of few separate parts.

I have already alluded to the improvements in pumps used for sinking purposes, for which I think we are greatly indebted to the mechanical engineer, and I have often asked myself how it is that we, as mining engineers, do not keep pace with him in improving our modes of sinking by using these machines. To this question I can only find one explanation, which to me seems to be that the number of shafts to be sunk by even the best of our mining engineers individually is not sufficient to cause them to concentrate their best efforts on the subject of sinking, and that consequently pit sinking is no man's business. I am led to this belief more strongly by the strides made in the modes and systems introduced and improved in connection with the production of coal and all that appertains to its production. Here the mining engineer's absorbing interest lies, and here, as a consequence, he uses his best energies, while the sinking of pits, after all, is only an occasional occurrence upon which he has no time to waste in devising new or untried methods. Hence we find splendid pumps being cut to pieces almost as soon as started under our present mode of sinking with them, owing to the great amount of sand passing with the water through them.

Some years since I formed the opinion that some of the sinking done in recent years would, on the whole, have been more speedily accomplished and at less cost if more time and money had been spent in preparing for the sinking. All around us we see large quantities of water being pumped

out of boreholes, and I don't see why this method could not be applied in draining the ground in advance of the sinking, more especially where the water is found near the surface. Where it is not found near the surface an extra pit could be speedily sunk to the water bearing strata, and the upper lifts of pumps could be placed in it. From the bottom of this pit boreholes could be put down through the water-bearing ground, and bottom lifts of pumps placed in them to drain the ground before sinking through it. Were this done, not only the very much greater part of the water could be raised without having anything to do with the sand or the sinking pits, but it could be also told by a comparatively small outlay whether the amount of water could be dealt with by the means available, and what the amount of water was likely to be. Under the present mode of proceeding, undertakings are sometimes ruined before such information is obtained.

The pumping of the water, apart from the sand and sinking of the pits, is quite a simple matter, and the sinking of pits comparatively free from water is also a simple matter, and both these conditions could be, at least in greater part, obtained by the draining of the strata in advance; and any feeders found in the main pits (which should be on the rise of the water pit or boreholes) could be conveyed into the bore holes free from sand when the sinking got below the feeders. In this way the main shafts could be put down comparatively free from water, and without the cost and trouble in connection with having the main pumps in the sinking pits.

I believe I am not far wrong when I say that the wages paid for attendance alone on the pumps in the sinking pits at some recent undertakings amounted to more than the sum required to put down the extra shaft and boreholes; while if we add to that amount the sum spent on pumps and

appliances to hang them in the shafts, and also the inconvenience, delay, and even danger, occasioned by the presence of steam and steam pipes, pumps, cisterns, buntons, &c., in the shafts during the sinking, and if we further add the extra time occupied through the presence of these things, the cost of the extra shaft and boreholes would appear small in comparison. Even places that are abandoned at present after immense loss of money, time, and trouble, had these preparations been made and properly carried out, would in all probability have reached the coal at a less outlay than it cost to make the futile attempt.

Under these circumstances, I think that the art of sinking is becoming a serious question to many; and it is likely to become more so owing to the importance of the deeper sinkings now in contemplation, and the still deeper ones to be made in the future; hence my humble quota to the all-important subject.

The CHAIRMAN: I think we are all indebted to Mr. Sutcliffe for his valuable paper. It is very interesting and I think in saying that, I speak the feeling of the meeting. We all know that the time is near when machinery, wherever possible in mining operations, must be introduced if we are to compete successfully with other countries. This invention is one of the things which I believe will prove a great success. I understand that at present it is at rest, but Mr. Sutcliffe has kindly offered to show the machine when it has recommenced working, and I am sure the members of the Society will be very glad to see it in operation. I have pleasure in proposing a vote of thanks to Mr. Sutcliffe for his valuable paper.

Mr. JOSEPH DICKINSON: I have much pleasure in seconding the vote of thanks to Mr. Sutcliffe. He is a Colliery Manager I have known many years, and I know

that he is well versed in most of the subjects which require a manager's attention. He has spoken of this machine as being understandable in structure, but he has had it at his finger ends. It will take some time for us to study it, and I think it would be well if we adjourned the discussion until the paper is in print and people will know a little more what it consists of.

The motion was passed.

Mr. SUTCLIFFE: I feel greatly indebted for the privilege of bringing a paper before the members of this Society, and for the kind way that you have received the paper. I hope I shall shortly have an opportunity of inviting them to some place where the machine will be introduced so that they may see it for themselves. As to the ultimate design of such machinery, I am not going to say that mine is the best. It is an attempt to overcome an acknowledged difficulty, and I believe it will do it, but at the same time I am not going to say that it cannot be improved upon. I believe that sinking is the only branch of mining that is neglected, and knowing well that I am in the presence of eminent mining engineers —Mr. Dickinson has had a life long experience in it—I feel I am not overstepping the point in saying that it is a neglected subject. There can be improvements, and because of the favourable disposition of the strata, sinking is capable of being done by machinery more easily than any other branch of mining that I know of. I am much obliged to you for the sympathetic way in which you have received this rough paper, which has been rather hastily got up.

The following paper "On Failures of Safety Lamps while in use and some of the disasters caused thereby," by Mr. JAMES ASHWORTH, M.E., was read by Mr. WILLIAM SAINT:—

FAILURES OF SAFETY LAMPS WHILST IN USE AND SOME OF THE DISASTERS CAUSED THEREBY.

By Mr. James Ashworth, M.E.

Papers to this and kindred societies on the subject of safety lamps have during the last few years, and in fact ever since the report of the Mines Accidents Commission was issued, consisted principally of descriptions of improvements in construction and simplification of parts, but the writer does not remember one which has had direct reference to a common danger which has hitherto remained unrecognised in this country. It is therefore with a view to showing that the laboratory experiments of M. Marsaut on the influence of firedamp when a safety lamp is suddenly immersed in it, or when, what is practically the same thing, firedamp suddenly envelopes a safety lamp, have had a very practical confirmation in the mines of this country and yet received no genuine attention, that the writer has prepared the present paper for discussion. In all English experiments most attention has been given to the discovery of those lamps which would give the best results when exposed to a high velocity of an explosive mixture of firedamp and air, under the impression that a lamp which will successfully withstand such tests must be capable of withstanding any exposure in a quiescent or slowly moving current. M. Marsaut however took a very different view of the case and made a very large number of experiments on safety lamps when suddenly raised into a firedamp atmosphere, but so little value was placed on these experiments by our own Mines Accidents Commission, and by other experimenters since, that practically nothing has been done to support or disprove M. Marsaut's conclusions. Some emphasis is given to the

importance of making safety lamps capable of withstanding very ordinary risks by the report of a recent enquiry in Germany, which will be detailed, and which will also introduce the question of the advisability of re-lighting safety lamps as soon as extinguished, by match arrangements within the lamp.

As a preface to the detailed descriptions of places and conditions surrounding safety lamp failures, it is to be observed that no explosion or great disaster caused by firedamp is so difficult to bring home to its primary cause with any degree of convincement as that caused by, or originating from, the failure of a safety lamp, because the traces of failure are either very faint or entirely absent, if the traces looked for are principally indicative of overheating, but fortunately we have authentic records of failures where the users of the lamps, or the men near by, have seen the failure occur, and have lived to tell the tale. Moreover, where the failure of a safety lamp is complicated by the presence of coal dust, the appearance of the lamp becomes still more misleading, as the gauze will be found extremely clean, and very probably showing little or no signs of overheating; thus a lamp passing the flame through the gauze when tested in an experimental gallery with a mixture of air, firedamp, and coal dust, at so low a velocity as 370 feet per minute, never becomes so hot as when firedamp only is present. This fact is probably due either to the formation of a large percentage of carbon mon-oxide within the lamp, or to the fact that the particles of coal dust are so small as to become incandescent in the burning mixture within the lamp, and to pass out in a regular stream of fire. Extremely few experiments have been made with safety lamps exposed to various velocities of mixtures of firedamp, air, and coal dust, and none whatever by any Government Commission, probably under the assumption

that a lamp which will stand a severe testing in gas and air will stand equally secure if coal dust is added, but that this assumption is erroneous will be clearly demonstrated by the facts now tabulated.

Davy Lamp Failures.

On the 30th of March, 1873, two men were at work in an air-way of the Old Mine at Bardsley Colliery, Ashton-under-Lyne, when an outburst of firedamp came off at a rent in the floor, and mixing with the air current ignited in the men's Davy lamps, and as they entirely failed to extinguish the flame, it quickly passed the gauze with the result that both men were burned and one of them was killed. The survivor told Mr. Dickinson, to whom I am indebted for these particulars, that "they tried but failed to put out the flame in the lamps, and that the best science man could not have done more than they did."

Another failure occurred at the Altham Colliery, near Accrington, on the 7th of November, 1883, and as Mr. Dickinson adds, it put the finishing stroke to the use of unprotected Davy lamps in his district.

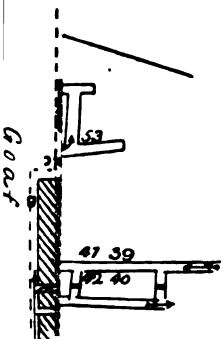
In this case, as in some others, the failure is a case of surmise, and it is not clearly indicated which lamp was supposed to have failed, but as the mine was at work it is certain that the ventilative current was carrying a normal percentage of coal dust, and that the conditions would be similar to those of the Bedford Colliery or of Bryncoch Colliery, which will be referred to later on.

Another failure of an unbonneted lamp is described by Mr. A. R. Sawyer, late H.M. Assistant Inspector of Mines for North Staffordshire, in a paper he read before the North Staffordshire Institute of Mining and Mechanical Engineers, on the Marsaut safety lamp (Fig. 14). On the 20th February, 1883, in the Great Row seam of coal at Great Fenton Colliery, he

took up a Davy lamp (Fig. 1) which was hanging at the face in a slightly dusty working, and gave it a tap with his hand, and in an instant there was a reddish flame of some magnitude inside the gauze extending to a distance of about 2in. outside the gauze of the lamp. Mr. Sawyer was so surprised that he says he should have thought it an optical delusion had it not been seen by the underviewer as well as by the collier to whom the lamp belonged. Two out of eleven explosions, by which one or more persons were killed, which had occurred in his district during the preceding five years, and as to which he could speak personally, were caused by the ignition of gas at a perfect Davy lamp. (The writer observes that Mr. Sawyer does not say anything about the influence of dust in the case of these failures.) He also named two instances, one in 1883 and another in 1884, when the accidental spilling of some gunpowder dust on the gauzes of Davy lamps caused the flame to pass the gauze and fire the bulk of the powder which was being used by the colliers.

A similar occurrence was in all probability the cause of the Udston explosion in Scotland in 1887. It was well known that two men named Dennison had a powder can and powder in it, but no trace of the can was ever found after the explosion. The indications of powder having been exploded in the working-place were so strong that the inspector of mines for that district (Mr. Moore) expressed and recorded his opinion that a shot had been fired, although he was aware that no trace of a borehole could be found nor yet any coal loosened by a shot. The lamp in use was a large type of Davy lamp, called a Scotch gauze lamp (Fig. 2), having a diameter of 3¼in., and which, when tested experimentally, gave no margin of safety in an explosive current of the lowest velocity.

Another Davy lamp failure caused an explosion on the 13th of August, 1886, at the Wood End pit of the Bedford



V. Jig, 1889.
severely burned.
Fig burned.

Figure 13.
Standard Belgian Mueseler.

AMPS CONTAINING
ARATUS.

Figure 14.
Marsaut Safety Lamp (Two Gauzes) with Bonnet removed.

Colliery, in the Crumbouke Mine, 3ft. 8in. thick, by which 38 lives were lost. In the morning men were engaged in one of the stalls taking out the back props, and after stopping for breakfast gas was discovered coming off out of the gob, but, without reporting it, they went on with their work. About 10-45, whilst a collier was loading some coal out of the way of the timbermen, gas was seen to fire in the Davy lamp, which hung from his waist strap and was swinging between his legs. The lamp was provided with a tin shield about three inches high, surrounding two-thirds of the gauze, but at this time was pushed up to the top so as to give more light, and as soon as the collier was warned that gas was blazing in his lamp, he took it in his hands and commenced to blow at it, *then shook it*, and the flame passed to the outside and fired the mine. The *collier was not burned, but killed by suffocation*, whilst the timberman who saw the occurrence and got out alive was only badly burned; the other timberman was also burned, but succumbed after running about 80 yards.

The timberman's escape from this accident is supported by another case quoted by Mr. Dickinson in his report on the above disaster, where two persons also escaped whose opened lamps ignited gas which caused the loss of 20 lives at the Bent Grange Colliery, Oldham.

Davy Lamp with Tin Shield Failure.

At the Bryncoch No. 1 Main Colliery, on the 4th of August, 1896, the Graigola seam of coal (5ft. 4ins. thick) was being worked at a depth of 435 yards by the pillar-and-stall method (Fig. 3). One of the pillars on the north side of the shaft had been partly removed, and, on the morning of the acccident, the strong rock roof began to break down where the pillar had been removed, and as it did so released a large volume of gas from a seam of coal which lies 19

yards above. The gas after a time came off in so large a volume that the colliers' lamps were extinguished, and the intake air was pushed back to the separation doors on No. 1 N.E. Three colliers who were working at the top end of No. 2 S.E. had their lamps extinguished, and instead of at once escaping, two of them, Nos. 6 and 7, sat down whilst the other, Lewis Jones, jun. (No. 5) went for fresh lamps. On his return with another man (W. Jones) and whilst running, the Clanny lamp (Fig. 4) was extinguished by the gas and was thrown away before they got to the two men who had remained in the workings, and who did not respond to the shouts of their would-be rescuers. They then returned to the level, where they met some colliers going outbye; from these they obtained two fresh lamps and also another volunteer, and again attempted a rescue, but with the same non-success as before. Whilst groping their way out they met two firemen (Nos. 3 and 4) and a repairer (No. 7), each with a lamp, and two of them (Nos. 2 and 5) again turned back to assist in the rescue. The two firemen carried naked Davy lamps (Fig. 1) furnished with small tin shields which surrounded about one-half of the circumference and about one-third of the height of the gauze, and the other man carried an ordinary unshielded Clanny (Fig. 4). The leading fireman hurried in, and from the statement of one of this party (No. 2), who survived for several days, they were all turning back when the explosion occurred. Every man dropped his lamp, the Davy lamp of the leading fireman (No. 4), being found the furthest in, and bearing unmistakable signs of over heating. Shortly before the explosion, and without knowing what was being done in No. 2 S.E., the under-manager opened the separation doors in No. 1 N.E. so as to break up the body of the gas which had backed down from the fall in the pillar working, and was showing itself on the intake side of the doors. By doing this he not only moved

the gas, but he also shortened the aircourse and thereby increased the velocity and the volume of the ventilation in No. 2 S.E., which though normally 1½ft. per second, became 6ft. per second, or enough, with adding the increase of velocity due to the movement of the retreating fireman against the air-current, to cause the failure of any of the lamps in use. The verdict of the jury was to the effect that the gas was accidently lighted by a partly protected Davy lamp; and that they had heard with satisfaction that the owners had dispensed with the partly protected Davy lamp (Fig. 1), and adopted a safer lamp for future use, viz., the Cambrian bonneted fireman's lamp (Fig. 1a).

It must again be noted in connection with this accident that although coaldust was not noticeably a factor of the explosion, yet that a very thin deposit of grey coloured dust was found after the explosion on the whole of the surfaces from the down-cast shaft along the south heading, and in from No. 2 S.E. southward to the main return leading to No. 2 pit. This latter element of grey dust was supposed to have been driven out of the gobs, but whether produced by the increase in the velocity of the air-current, that is from 1½ft. to 6ft. per second, or by the explosion, it is impossible to say with certainty. If, however, it were produced by the former cause it would exert an important influence on the explosibility of the gaseous mixture, as was proved by Professor (Sir) F. Abel in the course of the experiments made by him on dust after the Seaham explosion.

The influence of dust having been so clearly demonstrated, it is obvious that experiments which are made to represent, as nearly as possible, the conditions of a colliery roadway or stall must be incomplete without its inclusion. Also that sudden increases in the velocity of ventilative currents, as well as of sudden increases in the percentage of gas, must be factors to be considered.

Supposed Davy Lamp Failure.

On the 12th of February, 1900, a serious explosion of firedamp occurred at the Carbarns Colliery, near Wishaw. The presence of the gas was known and the men were not allowed to work. The manager, the oversman, a fireman, and an oncost man went down to try and complete an air passage, and whilst they were engaged on this work the explosion occurred. The manager was killed and others were dangerously injured. Mr. J. B. Atkinson, the Inspector of Mines for the East of Scotland District, informs me that the gauze of the fireman's Davy lamp was displaced from the lamp and has not since been found, and the fireman's body was 80 feet from his lamp frame. A survivor, over whom the flame of the explosion passed, coming from the direction of the fireman, said that the latter's lamp was lighted when he passed him on his way to the face where the gas was. It is supposed that the fireman left his lamp on the floor near where it was found and went forward in the dark, and that the lamp became overheated and passed the flame through the gauze, and so caused the explosion which damaged the lamp, and also that the gauze was probably under a fall, which occurred after the explosion.

If the surmise proved to be correct, the failure occurred under similar conditions to those of the Shakerley Colliery, when a bonneted Clanny failed, but the displacement of the gauze does not support this theory, and rather points to the failure of one of the other lamps as the primary cause.

Failure of a Stephenson Lamp.

On the 4th of August, 1885, in the Middleton mine of the East Ardsley Colliery (Fig. 5) in the early morning, the night deputy found a fall, B, which interfered with the free passage of the air through one of the banks, but no gas, and as a precaution he ordered the collier who was going to

work in the next bank on the outbye side to take a Stephenson lamp (Fig. 6) instead of the Clanny (Fig. 4) which he ordinarily used. About 9 a.m. the day-deputy found a little gas in the fast corner, A, but did not tell the collier working at C, and about twenty-five minutes past two, whilst the collier was moving his lamp to hang it on a prop or place it on the pack wall, the gas which had accumulated overhead fired through his lamp. The collier was very badly burned, and afterwards died, but the pony driver who was in the horse road and also badly burned, recovered. In this case the failure was probably due to the reversal of the air current within the lamp, caused by the upward diagonal movement, and experiment has proved that when such a reversal takes place the flame is crushed down on to the wick, the lamp fills with gas from the top, and as soon as this touches the flame the resulting explosion is so violent, being confined by the long glass cylinder, that it passes through the copper cap and the surrounding gauze without any perceptible delay. It is probable that some coaldust was also present, as the collier had been loading coal into a tub just before the accident happened.

Failures of Clanny Lamps.

On the 19th of May, 1894, at the Albert pit of the Allerton Main Collieries, five men—viz., the under-manager, a deputy, and three miners—were engaged in making preparations to remove some firedamp which had accumulated in the end of the east bord of the Silkstone seam of coal, above a fall of roof in broken ground where there was also a rise fault of 12ft. They first of all erected a fan at the end of some wooden pipes, 12in. square and 21ft. long (which had been used to ventilate the heading), so as to blow the air directly into the gas, and thus clear it out with the least possible delay. Soon after starting the fan they found that

one of the pipe joints was defective, and the under-manager and deputy proceeded to take off the brattice cloth which covered it, preparatory to putting in a new pipe, but almost as soon as they had commenced an explosion took place, and all five men were burned, one miner dying on the 24th, the under-manager on the 28th, and another miner on the 29th of May. Four of these men had Clanny safety lamps with metal bonnets, similiar to Fig. 7, gauze caps to the main gauze, and the inlet air ascending vertically through holes in the middle ring, as is customary in most modern safety lamps, but the fifth man had a lamp with a tin shield, and the inlet-air holes ⅛in. in diameter, placed in the side of the shield near its base. It will be seen, therefore, that the gauze of this latter lamp was imperfectly protected from the direct effects of an air-current, and as it was the lamp used by the under-manager and deputy when removing the brattice cloth from the joint, it was surmised that the lamp was close to the joint, that it was in a gas-charged atmosphere at the time, and that as soon as the brattice was removed a current of air of high velocity rushed out of the joint, and forced the flame of the burning gas through the gauze, and thus originated the explosion. None of the safety lamps were damaged in any way by the explosion, and were found securely locked.

Following the failure at Allerton Main, a more serious explosion occurred from a similar cause on the 1st of October, 1895, at Shakerley Colliery, Tyldesley, in the Trencherbone seam of the Wellington pit (Fig. 8), whereby five lives were lost. These were (1) the manager, (2) the under-manager, (3) the day fireman, (4) the night fireman, and (5) a dataller, all of whom were reported to have been very badly burned. No. 1 had a bonneted Clanny lamp, locked by a screw, and burning colza oil; Nos. 2 and 3 had similar lamps, but on examination after the explosion it was found that the gauze

of No. 3 (Fig. 7) showed marked signs of having been much heated—in fact red hot. It was furnished with a loose shield round the gauze, the oil vessel was not tight, and it took only two and three-quarter turns to screw it up. The glass was 2in. in diameter, the top and bottom ends being so carelessly ground that they were 1-16th inch out of parallel and at one point the light could be deflected by blowing between the glass and the asbestos ring. The gauzes were made of copper wire, and were found to be badly seamed, the main gauze being 1½in. in diameter and 3½in. long, surmounted by a gauze cap 1½in. long. The products of combustion escaped through holes in the circumference of the shield as well as vertically through the gauze cap, which was protected by a semi-circular hinged or tile top open at both ends. Nos. 4 and 5 had Protector Company's bonneted Marsaut lamps, locked by lead plugs, and burning colzalene spirit. All the lamps were found intact after the explosion. The circumstances leading up to this explosion were as follows:—Gas having accumulated in one of the districts of the Trencherbone Mine an attempt was made to clear it out, but this failing, the manager, accompanied by the four men before-named, went to remove it. The only air-current available for this purpose came from the Nelson pit through a very small airway, and it has been estimated that it did not exceed 1,000 cubic feet per minute, that this small quantity was further reduced by part of it escaping down the first brow, and that its velocity did not exceed 2ft. per second. At the point where No. 3's lamp was found the level was 6ft. wide by 3ft. 9in. high, and divided by a brattice cloth placed 2ft. from the higher side, the lamp standing on the return side and therefore in the larger space. The positions in which the other lamps were found led to the surmises, (*a*) that all the lamps excepting No. 3's had been extinguished; (*b*) that No. 2 went forward past

the end of the brattice without a light to remove some obstruction, and was rendered insensible by the gas; (*c*) that No. 1 rushed in to his rescue, and when only 8ft. beyond the lamp he had left behind, the latter passed the flame, and all were immediately killed by the succeeding explosion. This reasoning indicates that disturbances of gas and dust by such movements as those of Nos. 1 and 2 are quite sufficient to cause the passage of flame through similar lamps, when the gauzes are already overheated.

Another explosion originating, as the writer will endeavour to show, through the failure of a modern bonneted safety lamp, was that which occurred at Tylorstown, on the 27th of January, 1896, about half-past five in the morning, and which devastated Nos. 6, 7, and 8 pits. The consideration of this case is of great importance at a time like the present, when the practical safety of all the best-known explosives is being contested, and when the Tylorstown explosion is held up as a practical example of the failure of ammonite as a safe explosive in a fiery mine. The inquiry into the cause of this disaster was to some extent an exhaustive one, all the witnesses, including the colliery officials, the experts, and the Government inspectors, agreeing that the explosion originated in the west district of the Six-feet workings (Fig. 9), but the inspectors were the only witnesses who fixed the place of first ignition, and also its cause. The jury accepted the theory and evidence of the inspectors, and returned their verdict "that the cause of the explosion was the firing of a shot in gas in Daniel Williams' stall in No. 8 pit (Fig 10), and that the air passing along the coal faces was charged with gas, and probably coming in contact with a film of gas in Daniel Williams' road, and that the explosion was also accelerated by coal-dust. Also that no one now living is responsible for the explosion." This verdict, based on the evidence brought before the court,

proved the existence of the principal factors which affect the present inquiry into the safety of some of the bonneted safety lamps now in daily use in fiery as well as in non-fiery mines, viz., a ventilative air-current charged with gas, a film of gas standing in Daniel Williams' stall and road, gas standing in Skyrme's stall, which was two stalls away on the windward side, two firemen going round the west district on their usual round of inspection preparatory to the colliers going to work, and coaldust floating in the ventilative current. Both firemen were found in stalls where there was standing gas, and where also there were shots standing ready for firing (see Fig 9), viz., John Lewis (No. 17) in David Evans' stall and Richard Evans (No. 55) in Daniel Williams' stall. Only one man, named John Thomas (No. 46), a collier, was at work in the west district and on the leeward side of both the firemen; thus if John Lewis renewed a brattice, or did anything to move the standing gas in David Evans' stall, this would pass directly on to Richard Evans, and this increment, along with any gas set free by Richard Evans, would pass directly on to the collier John Thomas. Thus it will be seen that if Lewis (No. 17) set any body of gas free, it might reach Richard Evans (No. 55) after he examined a stall and found it safe for firing, and might thus catch him unawares when lighting the fuse, and in like manner John Thomas (No. 46) might be caught unawares. John Lewis had a bonneted Davy lamp with a moveable glass for shot-firing (Fig. 1a), Richard Evans a similar lamp, and John Thomas a bonneted Cambrian Clanny lamp (Fig. 7a). Both firemen were found on their faces, and in positions which they would not have taken up had they just fired a shot or were about to do so. Not only so, but the position in which Richard Evans' (No. 55, Fig. 10) lamp was found, entirely exonerates him from the charge of having fired a shot under such dangerous

conditions; thus his lamp was found undamaged on the floor, covered by fallen dirt, with the wick up, and at a distance of 3ft. from his body, thus proving that the lamp had not been dropped, and was not in his hands at the time of the explosion, but that it had been placed on the floor whilst he did something which required the use of both hands. If, therefore, the explosion originated in this stall, it must have been from the failure of the bonneted Davy lamp, and not from shot-firing. Mr. Robson, H.M. Chief Inspector of Mines for the South Wales District, based his opinion that the explosion originated in Daniel Williams' stall (1) on the cleanness of the stones which had been thrown down by the shot, (2) on the non-blackening of the roof, (3) on the general fact that has been observed, that there was little damage done to the workings in the immediate vicinity of the starting point of a large explosion, (4) that the lighting of the fuse had caused the first ignition of gas, or (5) that the shot itself caused the explosion of the surrounding athmosphere, which was charged with gas and dust in suspension. Now to show that these facts were not sufficient to prove that the explosion originated in Daniel Williams' stall, it is only necessary to note that this was only one of at least three shots which were fired at or about the time of the explosion, viz., the one already named above, one near where the fireman Lewis was found, and one about a mile away in the hard heading district of No. 7 pit. No fireman was near the latter shot. There is, however, clear proof that the explosion was not caused by any of the shots, because Richard Evans' body was thickly coated with coal dust, and his mouth was full also, whereas the stones thrown down by the shot were clean, and if the explosion had been initiated by the lighting of the fuse, Evans' body would not have been covered with dust nor in the position in which it was found, nor yet could his lamp

have been in the position where it was found, as it was undoubtedly a part of the shot firing, and would necessarily be in the fireman's hand. All the brattice sheets were blown away and no evidence was given as to where found, or additional light might have been thrown on the subject. Having shown that the facts were in the main opposed to the theory of the inspectors, it is necessary to diagnose some more likely theory based on facts which were agreed by all the witnesses. The main fact, then, is that the explosion originated in the west district, and as neither of the two points where the firemen were found satisfy the required conditions we must turn to the only one left, viz., where the collier Thomas (46) was at work. Here we find a place where the whole force and volume of the ventilative air-current, 36,360 cubic feet per minute, was concentrated, and where it was charged with all the gas and dust disturbed by the actions of the two firemen. The collier was ripping up floor about two yards from the face, and was found at the face, and, therefore had simply fallen without being blown in any direction, *his lamp was found intact, was not upset at all, the gauze on inspection was found to be clean and in good condition, free from oil, &c., the glass a little dirty, bonnet unbulged, and the wick up, thus proving that the lamp had not been dropped out of his hand, and that he had not been exposed to violence.* Thomas' body was only superficially scorched over the exposed parts, hair singed, face very red, and epidermis of hands loosened, in fact he was only as much burned as might have been expected at the place of origin of any gas explosion under like conditions. It should be particularly observed that the heat and dust were less in the collier's (46) place than in the one where the fireman (55) was found, and that if the first ignition had been by the fireman, the collier would have been exposed to greater heat and more dust. Moreover the injuries to the

doors in the Cochins road and in Bates' level were such as might be expected from an explosion originating in Thomas' place (46), as the flame would in the first instance follow the gas-laden air along the coal faces to the south-west on one side, and to the north-east and south-east on the other side into Bates' level, and the pressure would escape down Cochin's head.

Failures of Mueselers. (Fig. 13.)

The explosion at the Mossfield's Colliery, Longton, on the 16th of October, 1889, in a dry and dusty and very fiery mine called the Cockshead, gave very good indications that the failure of a Mueseler was the primary cause, and this assumption is most strongly supported by the succeeding example, which also occurred in the same seam a few miles to the north.

Explorers and experts who examined the Mossfield Colliery after the explosion were unanimously of opinion that the explosion originated in No. 15 jig, or in one of the levels at the top, but nothing was found to absolutely indicate how the ignition occurred. It was, however, proved in the course of the inquiry that the ventilation of this jig depended entirely on brattice sheets, and that the ventilation of the mine was being interfered with at the time of the explosion. Seven Mueseler lamps were supposed to have been in use by the persons working up the jig, but only six were afterwards recovered, one of which was broken and crushed. The man (No. 55, Fig. 11) working at the face of the north level *was only slightly burned*, whereas the other men on the south level (Nos. 50, 51, 52, 53) and 54 in the top heading were very severely burned. Judging from the evidence of the extent of the burning and from other circumstances which showed that the place where No. 55 was found was the point of least disturbance, the writer considers that there

was very strong presumptive evidence that the failure of No. 55's unbonneted Mueseler in the presence of a mixture of air, firedamp, and floating coaldust was the cause of the explosion. On reference to M. Marsaut's experiments it will be found that a Mueseler is not always a safe safety lamp in a quiescent atmosphere of air and firedamp, because it sometimes communicates the explosion to the outside by internal explosion in a stagnant explosive mixture, and it was this fact which mainly brought him to the construction of the lamp known as the Marsaut.

Mr. E. B. Wain, C.E., the general manager of the Whitfield Collieries, Stoke-on-Trent, has kindly furnished the writer the following particulars of the failure of an unbonneted Mueseler which occurred on the 9th February, 1886, in the Cockshead seam of that colliery.

An old road was being crossed which was very dusty, having been on fire five years previously.

A man was at work with a typical Belgian Mueseler hung up on a prop near the roof, and another Mueseler of English make was hung up in a similar manner a little further down the heading. A small fall of dirt took place from a hole in the roof of an old level where a small quantity of gas was lodged, and thus brought down this gas on to the nearest lamp which immediately fired the mixture, both

within and outside the lamp, resulting in an entirely local explosion and slight injuries to the man. After the explosion the lamp was found to be in a perfectly sound condition and the gauzes as bright as silver, whereas the other lamp was found covered with dust, thus clearly showing that the explosion within the first lamp had cleared all the dust away.

Mr. Wain says he had only left the place a few minutes when the accident occurred, and that it was the very dustiest place he had ever seen in a coal pit, the dust consisting principally of bind and shale which had been intensely heated.

He was also of opinion that under like conditions a bonneted Mueseler would fail in like manner. (With which opinion the writer entirely agrees.)

Failure of Marsaut Type Unbonneted. (2 Gauzes.)

The writer is indebted to Mr. Ronaldson, the Chief Inspector of Mines for the Western District of Scotland, and his assistant, Mr. Pearson, for the following particulars of the failure of an unbonneted Marsaut.

On the morning of the 19th of March, 1895, at No. 2 pit, Dalziel, Lanarkshire, worked by the Wishaw Coal Company, one of the firemen in the ordinary course of his examination of the pit before the men went in to work, found an accumulation of firedamp about 30ft. long, in a narrow heading which was being driven through a troubled piece of coal in the Splint seam, at a point about a mile from the pit bottom. This place was imperfectly ventilated by bratticing, when not assisted by the exhaust air from a pumping engine situated about six chains back from the face. The gross pressure of the air was about 40lb. to the square inch, the pipe conveying the exhaust air from the engine to the face

was $1\frac{3}{4}$in. in diameter, and terminated about 15ft. from the face. The pumping engine having been standing for some hours in consequence of repairs to the compressor, firedamp had accumulated, and as the colliers wanted their tools to work in another part of the pit, the overman, fireman, and one collier went in with safety lamps to fetch the tools. Whilst the fireman was in the act of putting up his lamp to the roof to test for gas, the engine was suddenly started, and the exhaust air issuing at a high velocity directly on to the lamp, which was already surrounded by gas with only a slight admixture of air, forced the gas so suddenly into the lamp that it was completely filled, and when ignited by the wick flame (which was probably reduced for testing), the violence of the resulting explosion was so great that the gas flame passed right through both gauzes. The accumulated gas thus ignited caused injuries to the overman, fireman, and two colliers, one of the latter being some distance away. The overman was watching the fireman making the test for gas, and distinctly saw flame pass out of the lamp. The lamps used by the overman and fireman were afterwards found on the ground, and were in good condition and so little heated that there was nothing to show which lamp had failed. The velocity of the air issuing from the exhaust pipe was measured by an anemometer, and found to be 600ft. per minute at a distance of 6ft. from the pipe, and at a distance of 3ft, 1,600ft. per minute. The whole pit was worked with safety lamps, and the lamps used by the overman and fireman were Protector Company's unbonneted Marsaut's of the following dimensions:—Outer gauze $4\frac{1}{4}$in. long by $2\frac{1}{4}$in. diameter at the base and $2\frac{1}{16}$in. at the top; inner gauze $1\frac{7}{8}$in. in diameter at the base and $1\frac{3}{4}$in. at the top by $3\frac{1}{4}$in. long; glass $2\frac{3}{8}$in. diameter by $2\frac{1}{4}$in. long. These dimensions are a little in excess of those adopted by M. Marsaut. The gauzes were flanged at the base but were

not strengthened by copper rings riveted to their base. The heading where this explosion occurred being thoroughly wet from water issuing from the coal and roof, coaldust was not a factor in the explosion, nor is it probable that it was present in the compressed air, as the screens were not at work and the compressor was fifty-five yards away from them, but it is possible that firedamp had accumulated inside the pipe as well as around it, and was forced on to the gauzes at a velocity of between 10 and 27ft. per second.

MARSAUT TYPE FAILURE. (Fig. 12.)
(Containing self-lighting apparatus.)

In consequence of an explosion of firedamp in a section of the Olga seam of the shaft of the Kaiser Heinrich Ferdinands Nordbahn Colliery, the origin of which accident was unknown, Bergrath Meyer, *Oesterreichische Zeitschrift für Berg-und Hüttenwesen*, was deputed to investigate the matter with a view to discovering the reason for the explosion.

The section in question is the most fiery portion of the colliery, and is situated between two extensive faults. The seam is about 68in. thick, the slope 30 degs., and the volume of gas liberated about 1,110 cubic feet in twenty-four hours for each ton of coal hauled, a quantity about equal to that of the most fiery pits in the Karwin district. The percentage of firedamp in the expelled ventilating current is sometimes as high as 0·75 per cent.

At the time of the explosion a hewer was engaged in trimming out a position for the erection of some timbering, by the light of a Wolf benzine lamp of the old type, with double gauze and *percussion igniter*. Although it was evident that the firedamp was ignited by this lamp, the immediate cause could not be ascertained owing to the contradictory statements of the miner, and the matter remained in doubt until a series of laboratory experiments indicated

the possibility of the ignition being caused by the *direct impact of a sudden rush of gas from the coal against the lamp, though the latter was in perfect order.*

The hypothesis that the ignition might have occurred through an outburst of flame from the lamp in consequence of the combustion of some of the ignition pillules on the lighting strip inside the gauze, was shown to be highly improbable by the tests made with the same lamp in a Schondorff apparatus, the lamp being lighted in an atmosphere containing 7 per cent. of firedamp and moving at a velocity of 5 to 6 yards, as also by the simultaneous combustion of eight of the pillules within the lamp in an atmosphere charged with 10 per cent. of firedamp. No outbursts of flame could be detected, although Spoth's experiments, made under more stringent conditions, showed that such outbursts from safety lamps are not impossible.

The following possibilities were assumed as the cause of the explosion :—

(*a.*) Rapid movement of the lamp and sudden contact, whilst charged with burning firedamp, against some hard object, either above, below, or in a horizontal direction, with or against the ventilating current.

(*b.*) Contact of shreds of clothing against the heated or glowing gauze in an attempt to extinguish the lamp. It should, however, be observed that, from the condition in which the lamp was found after the explosion, *it is improbable that the gauze could have been red hot.*

(*c.*) An outburst of flame from the lamp in consequence of the ignition of the pillules of the lighting apparatus, at the time of lighting the lamp, or withdrawing the pillules while the lamp was burning.

(*d.*) Through the influence of an outburst of gas directly impinging on the safety lamp.

Each of these four possibilities was investigated in a series of laboratory experiments which furnished highly interesting results:—

(*a.*) In this series it was found that explosions are of frequent occurrence when the percentage of firedamp exceeds 6 per cent. and the velocity is over 23 ft.

(*b.*) Here ignition first takes place in a 5 per cent. firedamp mixture and at velocities above 13ft. In the series *a*, *d*, *c*, no ignition occurred in lighting the lamp by the ignition pillules, even at velocities up to 39ft. and in 7 per cent. firedamp mixtures; neither was any outburst of flame from the lamp produced when 5, 10, 20, and even 72 pillules (the entire strip) were set off at once. No outbursts ensued on igniting the pillules in a 7·15 per cent. firedamp mixture and at the high velocity of 32 ft.; and only when the pillules were burnt away in five seconds, with the lamp exposed in the current for ten seconds, did any passage of flame to the outside occur.

The divergence between these results and those obtained by Spoth can only be explained by the supposition that Spoth obtained his ignition pillules from another source, and that they contained a stronger charge of fulminate. The condition of the lamp in question and of the appertaining strip after the accident was, however, such as to indicate some other cause for the explosion.

The circumstances are different when pillules are set off whilst the lamp is burning; in this event ignition occurs—though not regularly—readily at velocities of 20 to 23 feet, and in presence of 7 per cent. of methane. The friction igniter also produces ignition under similar circumstances in 7 per cent. methane mixtures, and at velocities of 24 to 25 feet.

The fourth series of experiments with gas outbursts, which are somewhat difficult to imitate in the laboratory, showed that in the case of gaseous mixtures with a velocity of 16 to 19 feet the light was invariably extinguished. On the other hand, *in a quiescent atmosphere* the impinging of a methane-free current at a velocity of 13 to 19 feet, frequently caused the flame to burst out, and this is the most probable cause of the explosion at the Heinrich shaft, more especially as similar outbursts are characteristic of this section of the seam, and the phenomena described by the miner coincide with what might be expected to happen from an outburst of this kind.

Testing Interior Igniters for Safety Lamps.

The objects of these experiments, by Bergassessor Balzer, *Oesterreichische Zeitschrift für Berg-, und Salinenwesen*, was to ascertain to what extent the lamps used in the Lower Silesian coal district are liable to flare when lighted by percussion igniters in a fiery atmosphere, and so produce explosions of firedamp. The three types of lamp tested were the well-known Wolf lamp, the Hübner lamp, and the Broucek lamp.

The experiments were conducted at the Glückhilf-Friedenshoffnung Colliery, near Harmsdorf, in an apparatus resembling that used in the series of tests previously made at Neunkirchen, except that an atmosphere of coal gas from the coke ovens was employed in place of firedamp, there being no available supply of the latter. This difference in the conditions affects the value of the results in so far as there is a greater tendency to flare on the part of the lamp in coal gas; and, therefore, the results are regarded as merely of relative value, though they certainly show that a

lamp which will satisfy this test can be regarded as perfectly safe under the less stringent conditions of work in a mine. The tests were made in an atmosphere containing 6 per cent. of gas, both quiescent and moving at velocities of 40 to 80 inches per second, the lamps being exposed for a minute to the action of the gas before lighting. The first pellet having been ignited, a second one was fired immediately in order to see whether the burning gaseous mixture within the gauze cylinder could thereby be caused to flare, *i.e.*, pass through the gauze; and a further number of pellets was ignited in quick succession until this result was obtained, or the gauze became red hot, or, finally until a sufficient number to demonstrate the safety of the lamp had been let off without a flare being produced. A further test of the liability to ignition on the part of pellets that have previously missed fire in igniters of the Wolf type, where the tape is mounted in a vertical position, was made, the tape being drawn up so as to leave several unfired pellets exposed to the flame subsequently produced by firing a pellet lower down the tape.

The results showed that, when used with a single gauze cylinder, the Broucek lamp was the least liable to flares, an advantage, however, neutralised by the uncertain action of the igniter, which frequently failed to light the lamp at all. In the case of the Wolf percussion lamp with 6 to 10 miss-fires (artificially produced in the manner described above) a flare occurred in almost every instance where only a *single* gauze was used, thus confirming practical experience as to the danger of explosion under these conditions in a fiery atmosphere. On the other hand, the Wolf friction igniter proved entirely safe under the same conditions. The use of a double cyclinder of gauze greatly increases the safety of the lamp, flares being then of very rare occurrence, and naturally still more infrequent in

firedamp, which is less inflammable than the coal gas mixture used. The production of flares by the ignition of miss-fire pellets can only occur when the tape is mounted vertically, since in igniters of the Hübner and Broucek type the pellets that have passed the striker are protected by the casing of the box, and cannot afterwards be exploded. Furthermore, with ordinary care on the part of the miner, there is no occasion to ignite a second pellet when the mixture of gas is found to be alight—a condition that should not fail to be noticeable, especially since it is usual to hold the lamp up close to the face in the act of lighting. Bearing all this in mind, it is evident that *igniters with coiled tapes are much safer than those of the Wolf percussion* type. In one or two instances, with the Wolf and Hübner (single gauze) lamps, a flare occurred at the first attempts at lighting, owing most probably to *the projection of sparks through the meshes of the gauze;* and should this be found to happen under ordinary working conditions, the safety character of these lamps *would have to be regarded as of a low order.*

All the Wolf lamps which are in use in England are fitted with the friction type of igniter (Fig. 12).

In reference to this type of safety lamp it is considered by some of Her Majesty's Inspectors of Mines that their use is not authorised by the present Mines Regulation Acts, and that no safety lamp ought to be provided with any arrangement which permits the user to relight it as soon as extinguished, whether the state of the mine is dangerous from excess of firedamp or otherwise. On the other hand, it has been pointed out by continental mining authorities that if all lamps in use had been fitted with re-lighting apparatus, many valuable lives might have been saved where men have been attempting to escape from the perils of the after effects of explosions.

Conclusions.

The safety lamp failures of which the writer has given particulars are, he thinks, sufficient both in number and detail to prove to the most sceptical mind that there is every possible difference between the margin of safety possessed by a safety lamp when exposed (1), to an atmosphere of firedamp and air, and (2), to one composed of mixtures of firedamp, coal-dust, or other dust and air. Thus the case related by Mr. Sawyer shows that under certain conditions flame may be passed through the gauze of a safety lamp with the aid of coal dust, without causing the explosion of the surrounding atmosphere, but firedamp mixed with air may be exploded many times in a similar lamp without much risk of passing the flame. When, however, these two dangerous components are coupled together the danger is greatly intensified, and such occurrences as Shakerley & Allerton, &c., become both possible and probable. The vast importance of knowing what is the margin of safety, if any, is evidenced by the experiments made by Mr. Hilton, at the suggestion of Mr. Gerrard, H.M.'s chief inspector of mines for the Manchester district, on the bonneted Clanny lamp, which failed at Shakerley. Mr. Hilton conducted these experiments in a testing gallery belonging to the Wigan Coal & Iron Co., Ltd., which is in all respects like the one used by Mr. Rhodes at Aldwarke Main, and he also made the conditions approximate as nearly as possible to those of the mine, but no explosion resulted, although the time of exposure of the lamp to an explosive mixture of coal, gas, and air varied from two to thirty-seven mintes. Further experiments were made in a still inflammable atmosphere, and continued for twenty minutes, but no passage of flame resulted, although the gauze was heated to a dull red. With the inflammable mixture moving at the rate of 2ft. per

second experiments were made for twenty minutes with a like result. Generally, as to the results of these experiments, Mr. Hilton says that "this accident requires it to be shown whether this type of lamp (Fig. 7) is safe in a still inflammable atmosphere." Mr. Gerrard also says "that in his opinion the Clanny lamp is not one of the best types of safety lamp, and moreover, that the cause of No. 3's lamp failing was not from any injury to any of its parts, but that it was the 'principle' of the lamp, and that this accident emphasises the importance of thoroughly testing whether the lamp is safe before permitting its use in fiery mines. Unfortunately so-called safety lamps were introduced without such a complete test as was, in his opinion, necessary. To go to a lampmaker's shop one sees all sorts and sizes of lamps, gauzes, and glasses. Although unshielded lamps are practically prohibited by the Act they are still used, it being almost impossible to obtain a conviction before the magistrates for such an offence. Mr. Gerrard further says that he hopes that the lesson taught by the Shakerley explosion will lead to such consideration and full recognition on the part of all connected with fiery mines, firstly, not to advance at all in an inflammable or explosive mixture with even a securely protected safety lamp, and so risk bringing on an explosion."

Bonneted Clanny lamps from Allerton Main, similar in construction to the one experimented on by Mr. Hilton (Fig. 7), were experimented on by Professor Lupton, of the Yorkshire College, Leeds, with explosive mixtures of air and lighting gas moving at various velocities, and forced on to the lamps by a fan, but no failure was recorded until a velocity of 50 feet per second was attained. This velocity was calculated from the reading of a water gauge placed between the fan and the lamp, and was not confirmed by an anemometer test. As in the

Shakerley tests, dust was not included in the experimental atmosphere, and therefore the only information obtained was, that a certain make of bonneted Clanny lamp would stand exposure to certain conditions for a certain length of time without failure. The conditions under which the tests were made were not materially different from those adopted by the Mines Accidents' Commission, when testing the very first lamps of the present bonneted type which were designed and submitted to the Commission by the writer on the 9th of May, 1882, and known in the Official Report as Nos. 17, 18, and 19, Clanny's. Nos. 17 and 18 were almost exactly the same in construction as the Shakerley lamp (Fig. 7), only that the latter had a copper instead of an iron gauze, and were tested up to a velocity of 1,926 feet per minute for 38 seconds, and to 1,500 feet per minute for 94 seconds, without failure, and No. 19 (Fig. 21 of the M. A. C. Report) which had a different pattern of shield or bonnet was only exploded with a velocity of 2,857 feet per minute after an exposure of 32 seconds. Now, although Nos. 18 and 19 were tested so long ago as August 4th, 1882, the writer does not consider that this represents their safety value excepting on paper, although as such it may be considered as comparatively very satisfactory. Just to show there are conditions not thoroughly understood which affect the safety lamp, another of his safety lamps may be referred to, viz., the Ashworth No 6 of the same report. This lamp was double bonneted and of the Mueseler-Arnould type. It was tested to 2,897 feet per minute, without failure, and a similar lamp was tested by Mr. Rhodes many times, also without failure, until one day when experiments were being made for some visitors, failure occurred, and it is doubtless a fact that the conditions were such that a larger percentage of gas than usual entered the lamp, passed up the chimney, and fired the mixture with which the outer cylindrical gauze

of small diameter and cubic contents was doubtless filled, and originated a very severe explosion in the apparatus. Knowing these facts, and also that during the course of experiments made by the writer in 1879, he had discovered that if a Davy lamp (Fig. 1) were exposed to a current of air containing only 4½ per cent. of fire-damp and only as much of 8 feet Bambury coal dust as a velocity of 370 feet per second would lick up off the floor of the testing gallery, and carry in suspension, it would allow the flame to pass through the gauze and explode the outer atmosphere in from 7 to 11 seconds without heating the gauze above a cherry-red. With a similar percentage of fire-damp and velocity, but with the coal dust eliminated, the Davy lamp could not be exploded. It is a most unfortunate circumstance that neither the Mines Accident Commission nor yet the Commission on Explosions from Coal Dust ever touched on the influence of dust on safety lamps, but its importance may be realised when we consider that the particles of coal or other dust always floating along in the air current of a coal mine, are so small that they pass through the gauze mesh without trouble, and if from any cause gas is burning within the gauze, or the gauze is in addition red hot, we do not require any great stretch of imagination to estimate what may result from such a combination. The writer does not think that people in general understand what is the most dangerous condition to which a safety lamp may be exposed in the everyday life of a coal mine, and therefore he may say that it is when a lamp is suddenly raised into an atmosphere of fire-damp containing very little air (see the failure of a Stephenson lamp at East Ardsley, Figs. 5 and 6), or when a ventilative current containing an excess of fire-damp suddenly surrounds a lamp, or approaching as a down current suddenly fills the lamp from the top and crushes down the wick flame.

Such a state of risk, especially if aided by a little suspended coal dust, is fatal to all lamps which admit of a reverse current being formed within the lamp. The Stephenson lamp is especially subject to this danger because the air supply below the glass is insufficient to feed the wick flame and to prevent a down current from the top of the lamp. Likewise this danger is brought before us very forcibly, by the explosion supposed to have originated from the use of self-igniters in a Wolf lamp (Fig. 12), which is confirmed by the tests made by Bergrath Mayer and Bergassessor Balzer and also by the tests made by M. Marsaut on lamps filled with an explosive mixture and fired at about the same level as the wick flame by an electric spark. M. Marsaut made 108 trials on his double gauze lamp, 92 without the shield and 16 with that appendage, and he obtained 12 exterior explosions or 1 in 9, and only his three gauze type resisted a total of 201 tests. These tests of M. Marsaut point out very clearly indeed that safety lamps, particularly those which are used by officials such as managers, deputies, firemen and timbermen ought to be provided with a much safer mode of bonneting, viz., one which will absolutely preserve the lamp from becoming filled with an explosive mixture from the top.

This contribution to an important subject which concerns the everyday life of a coal mine might be still further extended, but the writer thinks that he has provided sufficient subject matter for very careful consideration, and which ought to receive the attention of the Home Office Department in preference to legislation such as that which proposes to make compulsory the provision of locks incapable of being surreptitiously opened without detection, and which special rule, if passed, will sweep away all other means of locking, excepting the lead plug. He, therefore, now closes

the subject in the hope that the practical nature of the subject will receive the grave attention it deserves and that the following quotation from the 1894 Report of the Chief Inspector of Mines for the Yorkshire district (Mr. Wardell) may obtain practical application, viz., "The use of a safety "lamp which has been ascertained by experiment and "practical test to be the safest known lamp, ... and "the consideration of the treatment of coal dust, so con-"clusively proved to be a grave source of danger, more "especially when in conjunction with gas."

In a letter dated 30th April, Mr. Ashworth says:—

"Enclosed I hand you photos. of the Scotch Gauze, the Cambrian Fireman's lamp, and the Marsaut. The latter does not look very instructive as a Marsaut (2 gauzes), as the inside gauze is not delineated at all. The Cambrian lamp is however, very descriptive for the purpose of discussion, and it is one of those safety lamp constructions which to my mind is a parody on bonneting—the air inlet holes below the glass are not shielded in any way, the glass can be raised at will and *fastened up*, and lastly the bonnet can be screwed off without breaking any lock."

"With this latter lamp in mind and also the failures I have referred to in my paper, the wording of my article in the *Colliery Guardian* of the 20th inst. receives much emphasis."

Mr. SAINT said: We must all feel indebted to Mr. James Ashworth for this important paper, and I feel sure it will form a valuable addition to our transactions. I beg to move that a hearty vote of thanks be given to Mr. Ashworth for his valuable contribution.

Mr MATTHEWS: I have great pleasure in seconding the motion. I hope we shall have a very good discussion on the subject when Mr. Ashworth's paper again comes before the meeting There is a good deal to be said about safety lamps which has been mentioned in the paper. I know of one case where ten safety lamps were found unlocked in a mine. The fireman when going round found the old screw locks had been tampered with. The men were taken before the manager and owned that the lamps had been examined by the fireman in the morning and were then found to be locked, but it appeared that a boy had tampered with the locks by using a couple of nails for the purpose, which shows that the lead plug is much superior to the old screw lock for safety lamps.

The motion was passed with acclamation.

Mr. SAINT: I think it would be best to have this paper in print and all the diagrams with it, before we enter upon a discussion. It opens up a very wide subject, and Mr. Ashworth has expressed a desire to be present at a future meeting when it can be discussed fully.

Mr. DICKINSON: It is a very important paper and coming from Mr. James Ashworth, who has really made the improvement of safety lamps the study of a life, we could not do it justice to discuss it off hand to-day. I have much pleasure in seconding that the discussion be adjourned, but, if anyone wishes to say a few words here it will not interfere with the discussion.

Mr. J. McGEEVER: I quite agree that it has been the study of Mr. Ashworth's life. I have known him for 20

years personally, and all that time it has been his object to establish a good safety lamp, I think when the paper is printed we shall need to go through it carefully and we shall be able to understand it better then, than now.

The discussion was accordingly deferred.

This concluded the business of the Meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIX. VOL. XXVI. SESSION 1899-1900.

The ORDINARY MEETING of the Members was held on Tuesday, June 12th, 1900, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. LIONEL B. WELLS, M.Inst.C.E.,
(in the absence of the President) in the Chair.

NEW MEMBER.

Mr. JOHN R. RHODES, of Gorphwysfa, Prestwich, was elected a member of the Society.

The resumed discussion on Mr. THOMAS BELL's Paper "On the Working of Coal Mines under the Sea; also under the Permian Feeder of Water, in the County Durham," then took place:—

RESUMED DISCUSSION ON MR. THOMAS BELL'S PAPER ON THE WORKING OF COAL MINES UNDER THE SEA; ALSO UNDER THE PERMIAN FEEDER OF WATER, IN THE COUNTY DURHAM.

Mr. Bell gave the following additional information:—

At page 370, mention is made of the prospect of several large collieries being sunk and others opened out along the new line of railway.

Since writing the paper a Company has been formed, called the "Horden Collieries Co., Limited," with a large capital, to win and work a large tract of undeveloped coal of about 17,000 acres lying to the south of the whin-dyke under the royalties of the following estates:—Horden and Eden, Little Eden, Shotton, Castle Eden, Hulam and Nesbitt, Hesleden, and Hutton Henny, including the under-sea coal beyond the fore-shore; thus, practically all the coal along the Durham Coast from the River Tyne to Hartlepool, both inland and under-sea, is now taken or is under lease.

Operations have already been commenced to re-open the Shotton Colliery which has been laid in for about 30 years, and arrangements are being made on an extensive scale for sinking the "Horden Shafts," after which it is intended to proceed with the sinking of the "Hesleden Shafts," and the re-opening of the Castle Eden and Hutton Henny Collieries.

Sinking operations are proceeding at the Dawdon and Easington Collieries, already mentioned; at the latter place

they have reached a depth of about 50 fathoms, and it appears that the limestone is very full of open gullets and is giving off about 2,500 gallons of water per minute. This water is found to be very salt, and as the depth is below the sea level it looks ominous.

Arrangements have recently been made between Lord Londonderry and the North Eastern Railway Co. that the latter shall take over or purchase his Lordship's private line of railway, between Sunderland and Seaham Harbour, which joins the new line now being constructed by the Company to a point on their old line somewhere about Hartlepool. The Company will then have another and a shorter coast line of railway between the ports of Sunderland and Hartlepool, with Seaham Harbour New Docks between them, which will provide ample accommodation for conveying and shipping the produce, not only of the collieries in question, but also of a large number of other collieries in the immediate district.

Another Company has recently been formed to win and work the coal under what is known as the Fishburn Estate, which is on the south side of the "Butterknowle Dyke," and situated between the villages of Trimdon and Fishburn. This royalty lies to the extreme south of the coalfield, and has hitherto been untouched. Appended is an abstract of two boring sections made on the estate:—Comparing the two sections, and considering that there is little variation of the contour of the district, it seems likely, from the depths of the borings, that the 3 ft. 10 in. seam given by the Diamond Boring Co., is the same as that given by the ordinary boring above and marked "supposed 5/4 seam." There is no other proof that I am aware of, of the existence of coal in this locality than is shown by these two borings.

FISHBURN BORING.—Commenced in a quarry on Miss Chilton's Estate, about one mile east of Colonel Beckwith's Estate, 7th September, 1837:—

	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.
Limestone and Marl			266	0		
Strata—Coal Measures			33	9 ..	299	9
Coal	0	6				
Grey Metal	0	2				
Coal, foul	0	4				
Coal, rather foul	0	8				
Grey Metal..	0	1				
Coal..	0	10				
	——			..	2	7
Strata					117	11
Coal, foul	0	7	Supposed			
Coal	1	4	5/4 Seam.			
Coal, foul	0	4				
Coal, hard	2	8				
	——			..	4	11
Strata					96	0
Coal, strong (not named)					2	5
Strata					41	3
Coal, good	2	4	Supposed			
Coal, coarse	1	2	Main Coal.			
	——			..	3	6
Bored further					15	3
Boring stopped at					583	7
and resumed 24th August, 1840, when four thin seams of coal were met with, but were only from 4 to 12 inches thick					245	7
Total depth bored					829	2

January, 1873.—Another hole was put down by the Diamond Boring Company by Beaumont's new boring apparatus:—

	Ft.	Ins.	Ft.	Ins.
Sand and Clay	66	6		
Limestone	277	8		
			344	2
Strata, Coal Measures			69	6
Coal			3	10
			417	6

They state that they did not bore through the coal in consequence of breaking the rods.

I have, since writing the paper, extracted the following from the sinking records of the Murton Colliery, mentioned at page 376, which shows that the following engine power was fully employed:—

	Horse Power.	Horse Power.
1. North Main Pumping Engine	450	
2. South " " "	450	
3. East " " "	250	
		1,150
1. East Pit Machine	80	
2. Middle Pit "	120	
3. Polka " "	120	
4. West " "	60	
		380
1. East Pit Jack Engine	20	
2. Middle " "	20	
3. West " "	14	
		54
Total H.P. employed		1,584

It required 39 large boilers to supply these engines with steam.

There were 27 sets of pumps in use with working barrels varying from 16 to 19 inches in diameter, and the quantity of water delivered to bank was about 10,000 gallons per minute from a depth of 540 feet.

After the tubbing was got in and secured there was very little difficulty beyond the occasional blowing out of a little of the sheeting which was easily wedged again. A few years ago the acids from the underground furnaces and boiler fires affected the metal in the upcast shaft when it was found necessary to re-line this shaft, new tubbing being put in in front of the old tubbing.

Nothing occurred to disturb the level of the water in the shafts until about 12 or 15 years ago when the Sunderland Water Co. put down a pumping plant and station about one mile south of the Murton winning, and after working their pumps for some few years their area of exhaustion appears to have reached the Murton shafts and lowered the water behind the tub about 20 feet when it was found necessary to deepen their staples so as to command a necessary supply of water for their colliery consumption.

I have made an analysis of the various strata sunk through at a dozen of the deepest pits working under the Permian in the County of Durham, with the following result:—

	Per cent.
Thickness of Alluvial and Limestone	22
„ Red, Blue and Grey Metals	33
„ Posts or Sandstones	24
„ Harder Grey Metals	21
	100

Taking all the data into consideration, I must again express my opinion that I cannot see how there is any more danger from inrushes of water when working coal in the usual way under the sea than there is in working under the Magnesian Limestone feeders.

Mr. JOSEPH DICKINSON: On page 376 Mr. Bell, in his notice of the Murton Colliery winning in 1841, quotes the feeders of water as having been estimated at 10,000 gallons per minute, and he gives his authority, page 43, Vol. V., Trans. N.E. Inst. of Mining Engineers, 1856-7. This quantity of water being so enormous, I have been asked by Mr. Saint, who is unable to attend to-day, to enquire whether since the date of the authority the quantity has been in any way verified or varied. It would be unreasonable to expect Mr. Bell or any person to deal off-hand in discussion with such figures. I have therefore looked at the authority mentioned, and I see that in the earlier stage of the winning, when 3,285 gallons per minute were being pumped, the feeders were in excess of the power, and after consultation the power was increased until it reached 9,306 gallons per minute from a depth of 540 feet, 39 steam boilers (size unstated) being employed, the calculations being apparently from the size of the pumps and the rate of pumping.

Mr. BELL: I gave the quantity as 10,000 gallons per minute, but more details are given in the Transactions of the N.E. Inst. of Mining Engineers, in a paper by Mr. Potter, who was the viewer, and who sunk these pits. My object was to show there was not the danger that has always been apprehended from winning the under sea coal. I thought Mr. Dickinson was going to tell us of the danger of working

under sea coal, and it occurred to me to ask "Can there be any more danger in doing this than in working mines under the Magnesian Limestone?" We all know that in the latter case there is a large underground lake to be dealt with. Yet it has been worked successfully for a great number of years.

Mr. DICKINSON: Mr. Bell's paper is so complete in itself that I don't think there will be many of us who will have much to say in reference to it. I certainly have not.

Mr. A. DURY MITTON: I have been very much interested in Mr. Bell's paper. It is a good paper and is an important record of mining work in a district which has been somewhat unexplored until recently. I have been connected for ten years with some of the collieries he mentioned, and know something of the working under the Permian feeders, and what little water is seen considering the amount there is in them. In a shaft I remember we had some very strong tubbing, and it had to be re-set to straighten it owing to the great pressure of water on the shaft, but we managed to hold the water in. And at the southern end of the county I am connected with some of the Trimdon collieries, and know the feeders we have there in all the seams. Some years ago, before Castle Eden colliery stopped, I used to go there, and the feeders were large. But no doubt the opening out of these new collieries should assist the Castle Eden coalfield in dealing with the water.

The following paper "On the Mottled Carboniferous Limestone of Derbyshire," by Messrs. J. BARNES, F.G.S., and W. F. HOLROYD, F.G.S., was read by Mr. HOLROYD:—

ON THE MOTTLED CARBONIFEROUS LIMESTONE OF DERBYSHIRE.

By Messrs J. Barnes, F.G.S., and W. F. Holroyd, F.G.S.

Occurring in some parts of the outcrop of the Carboniferous Limestone of Derbyshire are some very curious and interesting bands of mottled rock. (*See Plate I., Nos. 1 and 2.*)

The one with which we propose to deal more particularly occurs in section in a small quarry near to an old disused lead works, known as the "Glory Mine," and situated on the road from Miller's Dale to Taddington at Priestcliffe Ditch, as well as in another quarry on the London Road about half-a-mile distant. A similar rock is also found at Matlock, but the mottling is not quite so well defined as in the case of the Priestcliffe Ditch specimens. It also occurs undoubtedly in other limestone districts.

Entering the quarry near the "Glory Mine" during a shower of rain, some very curiously mottled limestone was observed, and on a further search being made the bed was found "in situ," its thickness being about twenty inches.

The base of the bed consists of a fine grained light coloured stone of a greyish buff colour and of uniform texture, containing only a few fossil shells and occasionally portions of coral. (*See Plate I., No. 2, A.*)

This bed stops quite suddenly, and the mottled rock makes its appearance presenting the following characters when seen "en masse." (*See Plate I., No 2, B.*)

There is a light coloured and fine grained matrix similar to the bed underlying it with dark coloured irregularly shaped

patches of a fine grained limestone. The dark patches vary in size, from that of a pea to the size of one's hand, and the shapes are of all kinds, but very uneven and irregular.

In some cases the dark is cut off very sharply from the light by a dark line or narrow band, which is occasionally almost black, and which follows the outer margin of the patch.

In other cases there appears to be a more gradual passage from the light to the dark.

After continuing for about twenty inches in thickness the mottled limestone ceases and the same fine light coloured limestone begins again, the change from the mottled to the light being quite as sudden and sharply marked as its commencement.

The patches in the mottled limestone are more or less isolated and are not confluent, there is also a slight tendency for them to break along the line of contact with the lighter portion when struck with the hammer.

There is nothing in the patches, or about them, of the nature of a concretion, or of a rolled pebble, and the rock is quite distinct from the pebbly conglomerate described in a previous paper.*

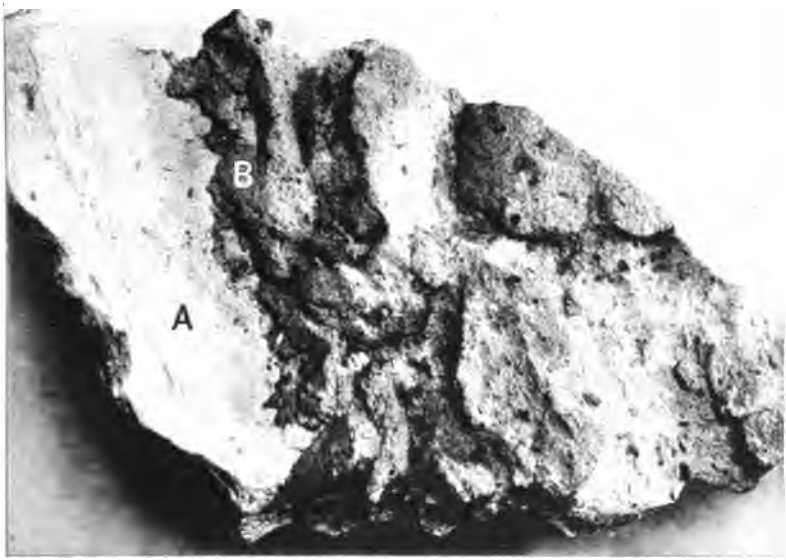
The appearance of the mottled bed led us to make some investigations with regard to it, first, as to the cause of this peculiar mottling, and second, as to its mode of formation.

The first thing that was done was to get out from the mass pieces of the dark part completely detached and free from the lighter part, and to determine the specific gravity of each.

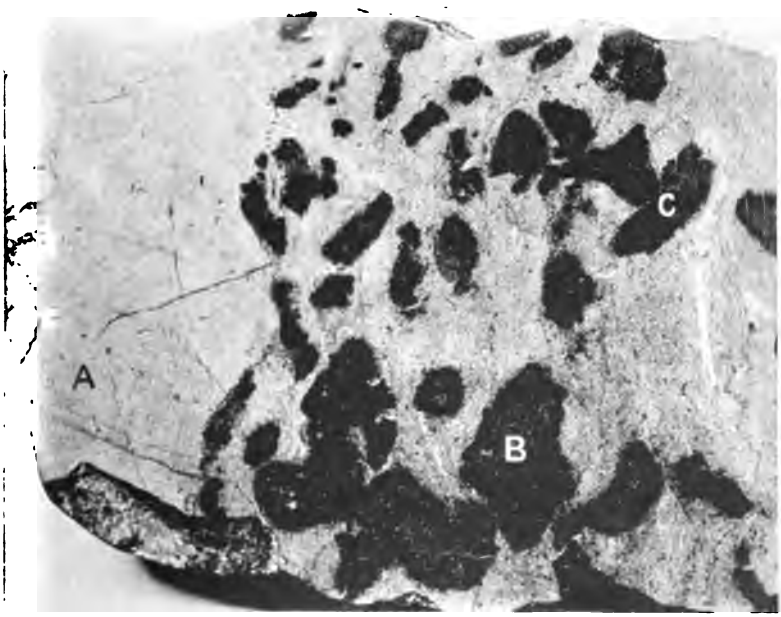
* See Trans. Man. Geol. Soc., Vol. XXVI., Part XVI.

Plate I.

Trans. Man. Geo. Soc. Vol. XXVI. Part XIX.
to illustrate Messrs. Barnes & Holroyd's paper.



1 *Weathered Surface (Natural Size)* A. matrix. B. patches.



2 *Polished Surface. (3/4 Nat Size)* A. matrix. B. patches. C. patch.

MOTTLED CARBONIFEROUS LIMESTONE. DERBYSHIRE

This gave the following results:—

DARK PART.

1st. Determination	2·703
2nd. ,, ...	2·702

LIGHT PART.

1st. Determination	2·702
2nd. ,, ...	2·703

So far as this physical property goes the determinations show the specific gravity of the two kinds to be the same.

A chemical examination was next made, and a great difference was seen to exist in the amount of the carbonaceous matter present in the dark portion as compared with the light. In the darker portion it was 0·146 per cent., whilst in the lighter portion only 0·046 per cent., or three times as much in the dark as in the light. This larger amount of carbonaceous matter may give rise to the difference in colour.

The amount of silica, lime, iron, alumina, and magnesia is similar in both samples.

Now, the fact that there is more organic matter in the dark part has a most interesting and wonderful effect upon the weathering of this mottled rock, for whilst the light portion is easily dissolved away, the darker resists the weathering to a much greater degree, as is seen in the specimen upon the table, and this is readily understood when we know that the hydrocarbon present acts as a water proofing, and so prevents the acidulated rain water acting so rapidly upon the darker part as on the lighter which contains only one-third the amount of organic material.

Following the argument further, we said there must be a cause for the greater amount of carbonaceous matter in the dark portion, and the greater amount could only arise from

the decomposed parts of either plants or animals, and as the naked eye failed to show any of the larger forms of either plants or animals, we had a large number of micro sections of the limestone prepared which revealed the following interesting characteristics.

In the lighter parts we see scarcely any signs of life at all, although rarely we do find an occasional foraminifer, but the general appearance is seen as in the photo—(*Plate II., No. 3*),—whilst in the darker part we find an altogether different structure, the field being crowded with life remains, foraminifera in abundance and the general appearance of the limestone itself quite different in texture. (*See Plate II., Nos. 1 and 2.*)

Here, then, you see we have a full explanation of the difference of the light as compared with the dark, *i.e.*, it is caused by the absence in the light part of the remains of foraminiferal life, whilst in the dark we have abundant life remains, and these in a most perfect state of preservation.

In both cases the matrix appears to be the result of a consolidation of a calcareous mud, but in the dark parts the calcite crystals are more numerous, and because of their greater transparency the section appears lighter.

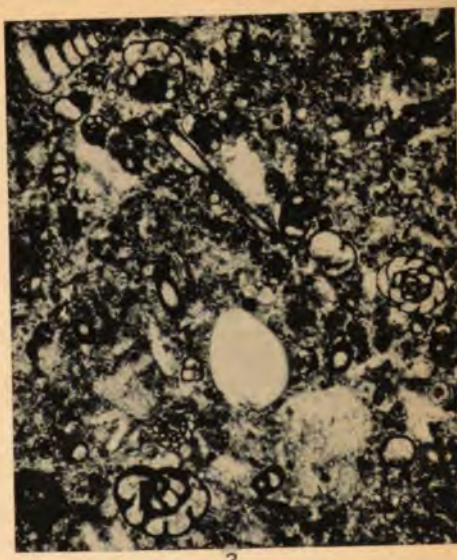
In the dark patches the variety of species of foraminifera is considerable, the specimens are large, and so numerous that several species are easily discernible on one slide. (*See Plate II., Nos. 1 and 2.*)

Now having settled the cause of the dark and light appearance of the rock, the next question is: What is the cause of the peculiar distribution of the dark and light, or what were the physical conditions which led to its formation?

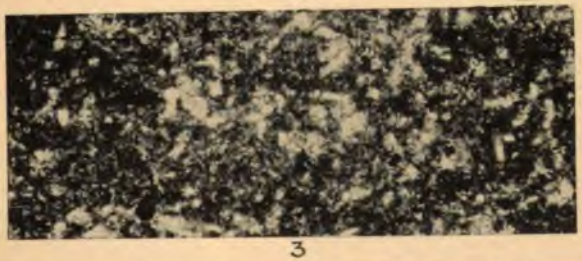
We think it will have to be admitted that the dark and light are not the same limestone, but that the dark has been

Trans. Man. Geol. Soc. Vol. XXIV. Plate II.
to illustrate Messrs Barnes & Holroyd's paper.

1



2



3

All magnified 15 diameters.

4

5

MOTTLED CARBONIFEROUS LIMESTONE, DERBYSHIRE.

removed from its original place of deposition and intermingled and cemented into the lighter matrix, because one cannot possibly imagine a sea, at the surface of which so many foraminifera lived and died, and in which their distribution after death upon the sea floor should give rise to what is now seen in the limestone, they would at least be arranged in something like regular layers, and not in the characteristically irregular fashion in which we now find them disposed.

In the discussion upon a former paper read by us at the March meeting upon the pebbles found in the Windy Knoll conglomerate, Professor Boyd Dawkins threw out the suggestion that the pebbles might possibly be patches of a partially hardened calcareous mud from the sea-floor, and this idea would seem to offer an explanation of the presence of the dark patches in the light matrix, and it is not difficult to believe that their origin is due to one of the volcanic outbursts that are found represented in the limestone, for upon the same or a very near horizon, as far as we are able to make out, there exists a bed of volcanic rock.

Given that these outbursts of volcanic activity were preceded by the usual earth shocks and sea disturbances, and the neighbouring presence of calcareous beds of dark foraminiferal mud, we have all the conditions necessary for the turning up from the sea bottom, and consequent removal to another area of the dark parts, together with the redeposition and consolidation, to produce the peculiar mottlings.

There are in the vicinity, beds of the darker limestone with the same suite of organic remains as are found in the dark patches—(*See Plate II., Nos. 4 and 5.*) Although it is not assumed that this bed was the one from which the patches have been derived, it proves that there were calcareous

muddy deposits rich in organisms, from which they might have been derived. These muddy deposits would vary in different localities, and it is assumed that a portion of a darker calcareous mud was torn up and distributed over an area of soft but lighter coloured deposit, into which it sank and became embedded; both afterwards becoming consolidated into the bed of limestone as we now find it.

In one of the specimens it is well shown that the now existing limestone must have been then in a soft plastic condition, by the fact that one of the patches (*marked C, Plate I., No. 2.*) is distinctly bent whilst falling upon another with its end pointed upwards.

The fact that both previous to, and after, the formation of the band of mottled limestone we have fine grained rocks points to some unusual temporarily existing physical conditions probably of a violent nature, that were capable of producing currents in the sea sufficient to remove the deposit from one part of the sea-floor to another.

With regard to the lateral extension of this mottled band we know but little.

It has been suggested that the markings might be due to dolomitization, but in the dolomitization of a limestone we have generally important physical and chemical changes. The limestone has its carbonate of lime partially replaced by carbonate of magnesia and ferrous carbonate. The fossils are to some extent obliterated. The percentage of magnesia and iron is increased, and the colour of the limestone appears of a dull dirty buff to brown colour. It is more earthy than crystalline, and more porous and sandy-looking than ordinary limestone.

On examining the mottled limestone in the various aspects enumerated above, it does not show at all favourably to the dolomitization hypothesis.

It has no increased percentage of magnesium carbonate, and it has not the physical appearance of the limestone which we know has been dolomitized and changed to dun-stone.

Dolomitization generally takes place for some distance on each side of a more or less vertical joint, becoming weaker further away from the joint on each side.

The mottled limestone lies horizontally, so evidently then, the mottling is not due to dolomitization as the mottled rock does not exhibit the characters of an altered rock, but it appears to us that the physical conditions of a transported calcareous mud best fit all the varied conditions of the problem.

The thanks of the Society are due to Mr. C. R. Lindsey for the excellent photographs which illustrate the paper.

Prof. BOYD DAWKINS wrote as follows:—"I regret that I am unable to be present when this paper is opened for discussion, and I therefore write to say that I have read it with very great pleasure. The authors indeed have left very little to be said on the matter. Their explanation of the mottling of the Limestone is, in my opinion, wholly satisfactory. I have examined the specimens and slides on which their paper is founded and can testify to the minute accuracy of the investigation. I am glad also to add that the authors of the paper propose to enrich our geological collection in the Manchester Museum with their series, and thus give an opportunity to members of the Society and to students of examining the whole collection."

The CHAIRMAN: I rise to move a vote of thanks to the authors of the paper. We are much indebted to them for the trouble they have taken in coming here and reading the

paper, and for bringing all these specimens which have been so carefully prepared.

Mr. JAMES TONGE, jun. seconded the motion and it was carried unanimously.

Mr. DICKINSON: There are two or three more papers to come on, and this is rather a long one to enter into a discussion upon. Perhaps, therefore, it is desirable to allow it to stand over until it has been printed, and then members will have an opportunity of discussing it.

Mr. MITTON: I agree with Mr. Dickinson that it will be best to wait till we have the paper in print.

Mr. HOLROYD: I think the suggestion very good, for some of the details of the paper are so technical that members, not quite so familiar with this branch of geological work as they are with others, will desire first of all to see and read the paper before making remarks on such a curiously difficult and unattractive subject. At a recent meeting Professor Boyd Dawkins showed very great interest in a paper I then read, and suggested that it dealt with a phase of our Society's work which was much to be commended. I may say I have been very much interested in reading a similar paper read recently and now published in the quarterly journal of the Geological Society, showing that a similar kind of work has been done for the Cambrian Limestone that Mr. Barnes and I have tried to do in the Mountain Limestone of Derbyshire.

Mr. SEBASTIAN SMITH exhibited and described a model and drawings of his patent safety catches, or props for preventing ill results in cases of overwinding:—

SAFETY PROPS FOR SUPPORTING CAGES IN THE HEADGEAR IN CASES OF OVERWINDING.*

Mr. MITTON spoke of the importance of this subject to all colliery managers. Instances of overwinding occurred occasionally and it was a wonder they did not happen much more frequently considering the thousands of times the cages were run up and down, and the rate at which they are run and that the slightest slip of the man in charge of the engine sends the whole cage into the head stocks. In those cases they had to rely on safety catches. These catches had to stand an enormous strain and there were very few collieries that had anything to fall back on to catch the cages. Realising the importance of the question he had asked Mr. Smith to let the Manchester Geological Society have an opportunity of seeing his model and hearing his description of it.

Mr. SEBASTIAN SMITH said he was very much obliged to the Society for allowing him to bring his model for inspection. He had been impressed with the risk of trusting to the ordinary means for catching the cages in the event of an overwind and considered that by the plan he had invented the risk was entirely removed, for the falling cage was thereby caught and held secure. By means of the model and drawings Mr. Smith showed how in a case of overwinding a system of catches was automatically brought into action. Props constructed according to his plan have

* See Part 3, Vol. XII., Transactions of the Federated Institution of Mining Engineers, for a description of this apparatus.

been, he said, severely and repeatedly tested with heavily-loaded full-sized cages and had acted perfectly each time. The props can be applied to any existing head stocks.

Mr. J. TONGE, senr.: I have pleasure in moving a vote of thanks to Mr. Sebastian Smith for his kindness in bringing this question before us to-day. From an examination of the model, and after listening to Mr. Smith's explanation, it seems to me a very perfect appliance for holding the cage in cases of such untoward events as he has mentioned. I think Mr. Smith has done a great service to the mining community in taking this matter up, and that his plan is a very great improvement on the arrangements previously in use. Of course we know there have been props and hooks used before, but I have not seen any that appeared so well adapted for the purpose as this appliance of Mr. Smith's is.

Mr. JOSEPH DICKINSON: I have much pleasure in seconding the motion. I am glad to have heard the description of this method of arresting the cage in the event of overwinding from Mr. Smith, who is well-known as having done his utmost to lesson the number and gravity of accidents in mines in various ways; but not having examined the apparatus closely it is very difficult to say in what respect it differs entirely from previous inventions. In my official report, as Her Majesty's Inspector of Mines, for the year 1879, when 115 disconnecting apparatus of various kinds were daily at work in the North and East Lancashire district, I gave a description of such of these inventions as I knew at that time, and I am not prepared to say how far this differs from one which I think was applied by the late Mr. Bryham, of Wigan. This invention was to disconnect the cage and allow it to drop on to catches. There was also another plan, in which the conductors at the

top portion approaching the pulley came sufficiently near to each other to wedge the cage between them. But one is always glad to see ingenious minds turning attention to the question of how to lesson the accidents in mines. Much has been done in this direction, but still one may hope that others will continue the good work.

The motion was carried unanimously.

Mr. SEBASTIAN SMITH: I thank you very much for your vote of thanks. If I may be allowed to say one word in reference to what Mr. Dickinson has said, I think the previous inventions provided props which hung out so as to be ready to catch the cage and it was a dead blow on the props, and I am afraid in those cases the blow would often be so great as to damage the head gear, whereas by my plan the cage is first caught between two wedges, so that there is no sudden hard shock, and there is no danger to the head gear.

Mr. DICKINSON: The lessening of the blow is certainly an important factor in cases of this kind where the force is something amazing. I remember many years ago at the Astley Pit, Dukinfield, a case of overwinding occurred when the counterbalance was disconnected for repairs; the cage shot up, passed the pulley, swung round at the end of the rope over the engine house, and fell into a reservoir at the back.

The following paper, "On the Makum Coalfield, Assam, with descriptions of the Collieries at present worked by the Assam Railway and Trading Co., Ltd.," was read by Mr. GEORGE E. HARRIS:—

ON THE MAKUM COALFIELD, ASSAM.

With descriptions of the Collieries at present worked by the Assam Railways and Trading Company, Ltd.

By Mr. Geo. E. Harris, M.E.

Although coal of superior quality has been known to exist in Assam for many years, it is only recently that steps have been taken on a large scale to open out and develop any of the known coalfields.

One of the earliest records, if not the first, of Assam Coal was made by Lieutenant Wilcox, in 1825, but this was of coal outcropping near the Desang River, some considerable distance from the Makum Field. This record, however, does not state the exact locality in which it was found, or give any particulars as to its mode of occurrence. Subsequent discoveries were made of coals outcropping in the rivers and hills, and about the year 1840, a small quantity of coal was quarried by the Assam Tea Company, near Jaipur, 20 miles south west of Makum. Small quantities of coal were apparently also raised in Makum about the same period, but little or no mention of the Makum Field was made until the year 1865, when Mr. Medlicott of the Geological Survey of India was deputed to examine and report on the Assam Coalfields generally. Although several fields are mentioned by him as being more advantageously situated, *i.e.*, closer to the rivers, than Makum (the rivers in those days being the only means of conveyance), yet, he reported "these advantages are outweighed by the superiority of the Makum Coal," which he considered to be *the* Coalfield of Assam.*

* Memoirs, Geological Survey of India, Vol. IV., p. 395.

Subsequently small quantities of coal were quarried in the Makum Field, near the Tirap river, which runs into the Dehing, but owing to the difficulties of transport nothing was extensively done. This will be easily understood, for, at this period, railways and tramways were unknown in Assam, and some of the rivers which empty themselves into the Brahmaputra are navigable only during the rains, or for about seven months of the year.

In 1874 and 1875, at the request of the Assam Government, Mr. F. R. Mallet, of the Geological Survey of India, made an examination of the Assam Coalfields. The Survey was made under great difficulties, the hills being covered with dense jungle, and owing to the unfriendly attitude of the hill tribes (Nagas), the party had to be provided with an armed escort of Frontier Police. This report which is very interesting and exhaustive, was afterwards published by the Government.* He gives a full description of the coal measures, which consist of alternating sandstones, coal and shales. The age is probably nummulitic. In the area under consideration, there is practically no limestone or ironstone, small nodules of the latter being very rarely met with. Fossiliferous foliage is often seen in some of the coals and clays. From the description of the coal seams given further on, it will be noticed that the "opening out" of the Collieries has proved seams of much greater thicknesses than were indicated by the outcrops. A peculiarity, frequently seen, at various points of the outcrops, is — coke and burnt earth. In the Tikak Colliery, hereafter described, about one mile in-bye from the mine entrance, the upper level driven against the outcrop (which is nearly 1000 feet above the plain), passed through some yards of coke.

* Memoirs, Geological Survey of India, on the Coalfields of Nagas Hill. F. R. Mallet, Vol. XII., p. 269.

Faults.—With the exception of a trough fault met with at Ledo, the seams are, on the whole, free from faults, a few rolls or swells being occasionally met with, but they are of no moment and cause little trouble. The strike of the seams follows the trend of the hills, and on the whole is fairly uniform.

Concession, Situation, Physical Features, &c.—Nothing was extensively done in Makum until the advent of the Assam Railways and Trading Co., Ltd., which, in 1881, was formed in London, to make a Railway about 70 miles long from Dibrugarh, an important town on the Brahmaputra, to tap the Makum Field. A Concession of 30 square miles was granted, to explore in, and open out the coalfield: which included the working of the oil, (known to exist since the time that coal was discovered) brickworks, sawmills, &c. The railway, which is metre gauge, commences at the Steamer Ghat, Dibrugarh, and runs to Makum Junction, a distance of 39 miles. Here it branches off in two directions, one branch of 16 miles going to Talup, connecting with extensive tea gardens, and the other branch going to Margherita, a distance of 23 miles. The track for 15 miles, until Digboi is reached, is through virgin forest. Margherita was the first clearance and settlement which the Company originally made in the vast stretch of forest in which the Makum coalfield lies, and is situated on the Dehing river, about two miles east of Makum fort, and 62 miles from Dibrugarh by the railway. It is practically the centre of the industries of the Assam Railway and Trading Co. Eight miles north of Margherita is the Company's oil territory at Digboi, and two miles south is the Makum territory. Adjoining the station are the Company's large sawmills, colliery workshops, and refinery; 4½ and 6½ miles east of Margherita are the Tikak and Ledo

Collieries and Brickworks, and south east lies the Namdang Colliery.

The Collieries are situated in the first spur of the Naga hills, in the Lakhimpur district. A good deal of coal and coke is sold locally, but the bulk is shipped at Dibrugarh, supplying the river steamers, and tea gardens on the Bramaputra. Some coal is also supplied in Calcutta to ocean going steamers. The Company's railway is the only one at present connected with the Collieries, but the Assam Bengal Railway is likely to be connected shortly, and will undoubtedly afford a new outlet for Makum Coal. Except where tea garden clearances have been made, the surrounding country is a dense forest and jungle. The south surface of the coalfield is undulating, the hills and valleys with numerous mountain streams forming a very picturesque country. The highest point at which coal is extracted is about 1,000 feet above the plain. In the immediate background are the Patkoi mountains, which enclose a pleasing panoramic view. On clear days, in the opposite direction, may be had an extensive view of miles of forest, interspersed with winding rivers. There are a few Naga villages on the hills near the Collieries. Previously the Naga population was numerous, but on the advent of the railway, a large portion of the population cleared away into the interior. The inhabitants of the immediate surrounding villages are friendlies, and more or less civilized. They are, as a race, incorrigibly lazy, having no industry of any kind. They cultivate, as a rule, sufficient grain for their own consumption. They are a hardy and strong race of people, but they do not care for work, and nothing will induce them to commence mining, consequently all labour has to be imported. A few of the local Nagas, who are more civilized than the rest, occasionally do jungle clearing. They are adepts at this work, and their services are gladly employed by Companies

who require heavy jungle clearances. The Assam Railways and Trading Company have made four clearances and settlements, near the mines, viz., Margherita, Tikak, Ledo, and Namdang.

Tikak settlement, which is the highest point of the outcrop, is 750 feet above the plain. There are about 500 coolie miners at Tikak. At Ledo the coolie houses are built, some of brickwork, others on iron rail posts, and some have brick pillars only, with bamboo sides and thatched roofs. The settlement is well drained by a small river, the Ledo, from which the name is taken. There are about 1,200 coolie colliers in Ledo at present. In addition to these there are the brick and pipe works people, as well as others who are employed on miscellaneous works—the total population being about 2,000.

Namdang is the newest clearance and settlement made by the Company for their Colliery at Namdang, the first coal being sent away in 1897. There are at present about 400 coolie miners here. The houses are placed on a hill some 250 feet above the mine entrance, and are much the same as those already described.

Collieries have been opened out east and west of the rivers Ledo, Tikak, and Namdang, and proved the existence of coal seams much thicker than were originally believed to be. The Ledo Collieries have been driven out nearly a mile, Tikak Colliery more than a mile, and the new Colliery at Namdang more than half a mile. With the exception of a seam of coal 8ft. thick, which has been worked at Upper Ledo Colliery owing to the erosion of the thick seam, the only coal worked at present is that known as the *thick* seam. This valuable seam is in reality made up of three or four seams, aggregating about 50 feet thick, and known as the top, middle, and bottom coals. The following is an average section of this seam :—

DIP 19° S.E.

Roof. Dark Clunch.

		Ft.	In.
Top Coal.	Coal	6	0
	Shaly Clay	2	6
	Coal	9	0
	Clay	3	6
Middle Coal.	Coal	3	0
	Clay	0	6
	Coal	8	0
	Clay	3	0
Bottom Coal.	Coal	2	0
	Clay	0	3
	Coal	4	0
	Clay	0	3
	Coal	18	0
	Floor. Clay	—	

The bottom coal has been found to be most uniform in thickness; in some places, the middle and top coals being eroded, and in others, where the top coal is found to be thin, the middle coal is generally found to thicken and *vice versa*. At Namdang, the coals are rather thicker than those at Ledo.

The following section is taken at 200 yards in-bye from the mine entrance:—

DIP 45° S.E.

	Ft.	In.
Coal	22	0
Clay	3	6
Coal	10	0
Fireclay	2	0
Coal	4	0
Fireclay	10	6
Coal	16	0
Fireclay	4	6
Coal	14	0
Fireclay	7	0
Coal	13	6

The section of coal at Namdang taken south of the thick seam and at present unworked is as follows :—

Dip 76° N.W.

	Ft.	In.
Coal	13	6
Shaly Clay	1	5
Coal	2	4
Shaly Clay	4	3
Coal	12	9
Clay	1	11
Coal	25	0
Shaly Clay	6	6
Coal	6	6
Clay	3	0
Rock	—	

The dip is the reverse of the other, and very steep, viz., 76°. The seams correspond with those of the thick seam and indicate either very sharp faulting or folding. In addition to the thick seam, already described, there are in the thicker portions of the hill several small seams, varying from 2 to 6 feet thick, the aggregate being about 30 feet. The distance between the Tirap and Namdang is nearly six miles, and the obtainable breadth above water level about 400 yards. The average thickness being about 80 feet, gives a total of 90 million tons. Deducting 2¼ million tons already extracted, and allowing one-half for loss in working, there remains an available quantity of over 40 million tons to be gotten, and all above water level.

Some of the fireclay is supplied to the Company's brick and pipe works.

The coal is an excellent steam coal, and undoubtedly the best found in India, its calorific value being considerably higher than any other known Indian coal. It cokes freely, the coke being of excellent quality. The analysis of the

outcrop coals made by the Geological Survey of India averaged:—

Fixed Carbon	60·5
Volatile matter	34·8
Ash	2·2
Water	2·5
	100·0

After mining operations had been commenced, a further analysis was made of the coal taken from inside the mine, the results being:—

Fixed Carbon.	Hydrogen.	Oxygen and Nitrogen.	Sulphur.	Ash.	Water.
75·70 ..	6·04 ..	13·11 ..	1·39 ..	1·12 ..	2·64

Gas per ton	10·900 cubic feet.
Illuminating power	17·2 Sperm candles.
Coke	11 cwt. to the ton.

It will be seen from the above, that Makum coal compares very favourably with best English coals.

The seams are highly inclined, those at Tikak and Ledo being about 1 in 3 (19°), dipping south east. At Namdang the seams are very steep, viz., 45°. A peculiar feature of the coal is its fineness when extracted. In the "whole" it is fairly hard and compact, the roadways standing well, little timbering as a rule being necessary if the roads are not made more than about 6 feet square, but in the broken a large portion of it breaks up into very small pieces, resembling fine slack. Owing to its cleanness and excellent coking qualities this is not of much consequence. It, however, causes a good deal of anxiety in mining, as fires from spontaneous combustion are very frequent. In addition to the coal seams already described, there is, in the plain, about half a mile north of the outcrops in the spur of the hills, another outcrop of the thick seam. The inclination is 45°, but the

direction is N. W. or the reverse of the other seams. Between these outcrops is half a mile of undulating barren ground, the break being an anticlinal fault, which can be traced along the foot of the hills for some miles. A good deal of the outcrop of this latter seam was quarried by the Company from 1884 to 1886, a thickness of 40 feet having been proved. Owing to water in these workings they were abandoned, directly the Collieries in the hills had been opened. This seam, no doubt, will be worked in the distant future. Inclines and shafts will have to be made, the working cost being greatly enhanced by the addition of large pumping plants which will be inevitable owing to large quantities of water that will be met with in dip workings.

Description of the Collieries, Systems of Working, Notes on the Labour, &c.

Ledo Valley Colliery (East).—At this Colliery the coal outcrops are seen in the bed of the river Ledo and in the rocks on each side of the river. The coals on each side of the river are similar in thickness, inclination, and their respective properties, and it is evident that at one time they were continuous, but they are now divided by the valley formed by the river Ledo. The main hauling road enters the coal at the lowest water level, *i.e.*, some 12 feet above the Ledo river bed—which is clear of the highest flood level, and is driven along the line of strike for nearly a mile. Thirty yards to the crop the return aircourse is driven parallel to the main hauling road, thirls connecting them at distances of 40 yards. Brake roads are driven up from the main hauling road slightly to the slant (to avoid steep hills), at various distances in-bye, and roads similar to the main roads are driven out from the top of the inclines to fixed boundaries, and the coal extracted.

Ventilation.—The Colliery is ventilated by a 10 feet diameter improved Schiele fan, open running, coupled direct. The engine cylinder is 9 in. × 12 in. Steam is generated in Lancashire and Cornish boilers. Firedamp is met with in this Colliery and safety lamps of the bonnetted Clanny type are used. They are fitted with patent burners for the use of kerosine oil.

Haulage.—This is effected by means of self-acting inclines and on the levels by ponies. A little tramming is done by coolies, but for short distances only, *e.g.*, attaching tubs to ropes, or moving them to and from the working places to the main hauling roads.

Ledo Valley Colliery (West).—On the west side of the river Ledo, entering the coal immediately on the side of the river, a little above water level, another Colliery has been opened out. It is now out nearly a mile. The breadth of the mine is about 300 yards, its upper boundary being Upper Ledo Colliery.

Ventilation.—This Colliery is ventilated by a Walker's Indestructible Fan, fitted with their anti-vibration shutter. The Fan is 8 feet diameter, with double inlets and an iron casing, the air being discharged into an expanding chimney. It is driven by a belt from an engine, the ratio of fly-wheel to the driven wheel being $2\frac{2}{3}$ to 1. Steam is generated in a 20-h.p. boiler of the Locomotive type. Gas has been found in the upper seams of this mine only. Safety lamps, of the kind already described, are in use in these seams. A 16-h.p. vertical boiler is kept in reserve.

Haulage.—The systems of haulage are main and tail Rope, self-acting inclines, and ponies. The main and tail rope works 1,000 yards of the main hauling road. The engines are by Wood and Gee, of Wigan. They are self-contained,

the drums being on the same shaft. The hauling ropes are $\frac{3}{4}$ in. diameter, and are made of plough steel.

The loading wharf is situated half a mile from the Colliery entrance. A tramway, 2 feet gauge, connects the wharf with the Collieries, the coals being hauled by small locomotives, with cylinders $5\frac{1}{2}$ in. diameter × 11 in. stroke. The weight of each locomotive when loaded is about five tons.

Upper Ledo Colliery.—This Colliery is situated at a higher level than Ledo Valley West Mine. At a distance of half a mile in-bye a trough fault was met with, the thick seam being entirely eroded. This seam, which is 50 feet thick at the mine entrance, diminishes to 30 feet thick as it approaches the fault. The fault has been crossed and the full thickness of the seam, viz., 50 feet, found at a distance of 100 yards.

Ventilation.—This is effected by a small fan of the Schiele type, double inlet, with spiral casing.

Lighting.—Naked lights are used throughout this mine,—except for inspection before commencing work.

Haulage.—Main and Tail Rope, which works a thousand yards of the main road, self-acting inclines and ponies. The haulage engines and ropes are similar to those already described. The entrance to the mine is situated about 140 yards above the loading wharf, the coal being lowered by a series of self-acting inclines.

Tikak Colliery.—This mine, which is situated 750 feet above the plain, is approached by two inclines, the lower one 330 yards long, and the upper one 590 yards long. The Colliery has been driven out over a mile, and is free from faults.

Ventilation.—This is caused by a Schiele fan, open running, 10 feet diameter, coupled direct to the engine. Steam is generated in boilers of the vertical type.

Haulage.—This is done entirely by self-acting inclines and ponies. The wharf is situated about a mile from the mine entrance, the coal being hauled by small locomotives, and led on to the wharf by the two inclines already described.

Namdang Colliery.—This Colliery has only recently been opened, and the headings are at present driven out a little more than half a mile. The loading wharf is situated a mile from the entrance, the coal being hauled by small locomotives.

Temporary ventilation is caused by a small furnace built on the side of the hill, but a fan is in course of erection. It is one of Walker's Indestructible type, 10 feet diameter, double inlet, and fitted with their anti-vibration shutter, and driven by cotton ropes from duplicate engines, fitted with condensers. The driving and driven wheels are 12 feet, and 5 feet diameter respectively. Steam will be generated in Lancashire boilers.

Coke-Plant.—A small coke plant is at work at this Colliery. There is no screening of the coal, the small and large coal as filled underground all passing through a Devil disintegrator, which crushes the bigger lumps to a uniform size. After crushing, it is washed in an Elliot Machine. Coke ovens of the bee-hive type are in use. They are 8 feet diameter placed back to back, with flue between. At present the demand for coke is small. The coke is of excellent quality, and as this becomes better known, the demand will undoubtedly increase. At present it is used in the Company's Railway Foundry, and on tea estates, where certain kinds of tea drying machines are adapted for the use of coke.

Tramways.—The tramways at all the Collieries, both underground and on the surface are 2 feet gauge, rails 22lbs. per yard, being exclusively in use underground. Where Locomotives are employed on the surface disused main line rails 41¼ lbs. per yard are in use.

Tubs.—The tubs are of iron 4 ft. 6 in. × 3 ft. × 2 ft., with Hadfield's steel wheels 12 in. diameter fast on axles, 1⅝ in. diameter. The side and end plates are ⅛ in. thick, the bottom one $\frac{5}{16}$ in. Loose couplings are in use. The tubs hold about 12 cwts.

Ropes.—Steel ropes ¾ in. dia. are exclusively used, with the exception of the big incline rope at Tikak, which is 1 in. diameter.

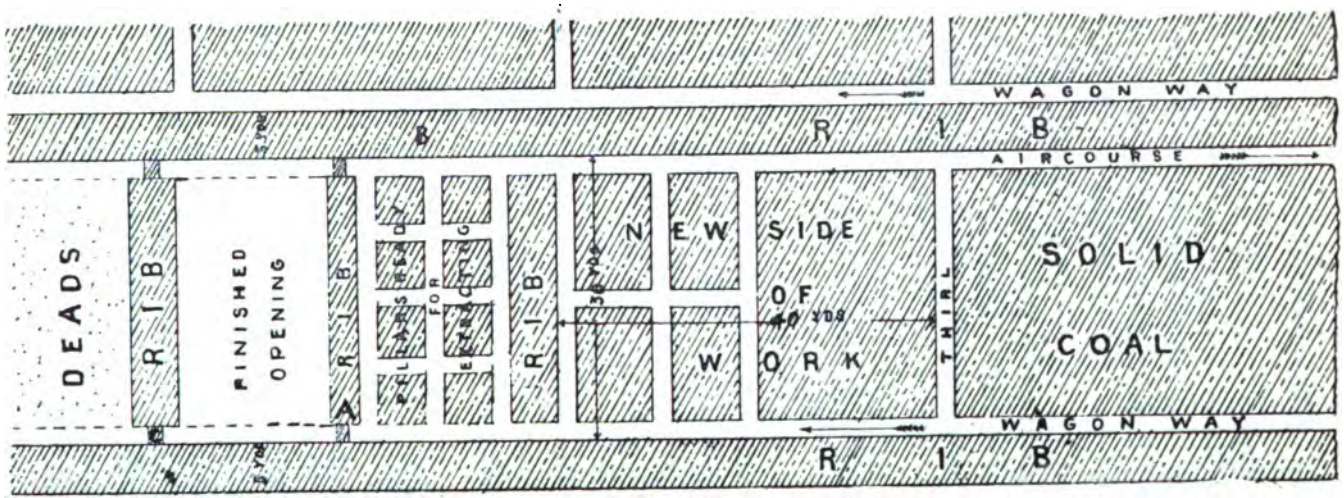
Lighting.—Safety lamps of the bonnetted Clanny type, fitted with patent burners for kerosine are used in the collieries where gas is met with. For the inspection, before commencing work, bonnetted Marsaut lamps are used. In all other places, naked lights are used. They are wax candles, and small tin lamps (battis); these lamps hold about 3 oz. of kerosine. Both candles and kerosine are manufactured at the company's refinery, and are supplied free to the miners.

Platelaying.—This is done by coolie platelayers, who do their work very creditably.

System of Working.—One of the special features of this coalfield is that dip workings, at any rate for a good many years, are unnecessary, and although the mines give off large quantities of water, still all workings being to the rise, and the drainage natural, pumping is not required. This is a very considerable saving in the working economy of the collieries. The seams being the same at each colliery, the systems of working in vogue are analagous. In the working

of the coal in the "broken" (openings), various modifications have been found necessary owing to local conditions, *e.g.*, little overburden or cover (which varies from a few feet to several hundred feet), great thickness of the seams, with practically no sound roof, and the liability of the coal to spontaneous combustion. It will be understood that these cause much anxiety, and the strictest care has to be exercised in the working. The system adopted is square or panel work, something similar to the system employed in the South Staffordshire thick coal. The *modus operandi* is to drive out on the thil of the bottom coal, two main roads, 6 feet square, and about 30 yards apart, on the strike of the seam. The lower of these roads serves as the main intake, and also main haulage road or gateway. The upper road is the return air course or outtake. The roads are connected by thirls at about every 40 yards. From the main levels, brake-hills or inclines are driven, slightly across the dip of the seam (to avoid steep hills) to a safe distance above the main return aircourse. From the top of these brake hills, roads are driven out similar and parallel to the lower main roads, to a fixed boundary. The measures are then crossed into the top coal, which is first extracted in the following manner :—

"Sides of Work" are formed usually about 40 yards (*See Plan*), which are subsequently divided into smaller sides. The side is then cross-cut and subdivided into pillars in all directions. There is no holing or kerving. The first row of pillars or knobs is then paned off, until the pillars are about 2 yards square. Before the pillars are reduced, the coal is cut up usually on three sides, against the ribs, to a height of from 12 to 16 feet. The first row of pillars is then taken out. If the overhanging coal does not then drop by its own weight, the operation is repeated in the next row of pillars. Generally the overhanging coal falls



A This rib sometimes taken out if no firestink is present in Gob.

B If no fire in openings below, most of this rib is taken out with next side of work above.

C Sand and Masonry Stopping.

Scale, 60 feet = One inch.

after the second row of pillars is taken out, if not the roof coal is blasted down. After the openings (sides and roof) have been examined and any loose or dangerous pieces made safe, the coal is filled out as rapidly as possible. The operation is repeated in the next "side" until the "shut" or "waste" becomes large, or "firestink" is perceived. The whole "side of work" is then dammed off by means of masonry and sand stoppings in the main roads, a protecting rib of solid coal being left against the deads. For extracting the pillars prickers and bunters about 12 feet long are used. The coal is filled into the tubs by men and women, shovels, kodalis and baskets being used. After a certain area in the upper seam has been extracted, the same operations are repeated in the bottom coal, a portion of the middle seam being gotten with the bottom seam, the upper portion of the middle coal forming a protection against the upper coal workings. If the top coal breaks through a fire invariably occurs, and the "side" has to be abandoned. All the "driving" and "getting" is done by men. Each "opening" is in the charge of a "Sirdar" or chargeman, who has had considerable experience of the work. "Chocks" or "Cogs" are seldom used. The timbering is done by a separate gang of timbermen kept specially for the purpose. Timber is obtained from the forest around the mines. English firemen exercise daily supervision of the collieries. Dynamite is the explosive used in driving rock tunnels.

In 1885 the output of coal was 43,000 tons; 1890, 145,700; 1895, 173,500; 1899, 228,000 tons, giving an average of about 10 cwt. per person employed, including surface and underground, daily. This is higher than the average of most Indian Collieries.

Labour.—Undoubtedly the great drawback to enterprise in Assam is the scarcity of labour, the Colony being very

sparsely populated. Local labour is not obtainable, and it is therefore necessary to import coolies from the congested districts of Bengal, &c. The want of labour in Assam is seriously felt by all industries, and is, in most cases, a very expensive item in their working economy. More especially is this felt in coal mining, the conditions of work being so totally different to most kinds of work. The coolies being essentially agriculturists, they do not, as a rule, at first take kindly to colliery work. This is readily understood under the circumstances.

In England and on the Continent the collier commences work when quite a boy, and gradually gets initiated into the various operations underground. In Assam, the collier has to be imported, and put to work to which he has never been accustomed. The average age of the imported coolie is from 18 to 25 years, and to have to commence using a pick at this age, goes against the grain. Some of the coolies take kindly to the work, and, as a rule, when once accustomed to it, make very good miners. Various castes are imported. Sonthals, Moondas, Ooraons, Kols, and Bowries make the best colliers, but good miners are also found in other castes. The castes mentioned are hardy and strong, and stand the varying climate uncommonly well. They are well paid, although the wages to a European would seem very low,—but in addition, the coolie has to be found house accommodation, and medical attendance, and partly fed and clothed by the employer (by no means a small item in the working cost of an enterprise). This is not compulsory in other Indian coalfields. In Assam, the labourers are imported under an agreement, binding them to work a certain period. This is rather trying to the lethargic Indian coolie. Wages are paid monthly, the rates being:—

	Rs.
Sirdars or chargemen	14 to 18
Coal cutters and opening men....	8 „ 13
Fillers	7 „ 9
Timbermen	8 „ 14
Brakemen and rope followers ..	8 „ 12
Engine drivers and boiler attendants	12 „ 16
Banksmen or wharf men	8 „ 10
Platelayers	8 „ 13
Pony drivers..	7 „ 9
Women :.	6, 7 & 8
Boys	5 „ 6

(The present value of the rupee is about 1s. 4d.)

It is a great pity that the local labourers (Nagas and Assamese) won't attempt mining, as they would be able to earn good wages. Higher rates of pay could be given to local labourers than those paid to imported labour, as the cost of importation, which is a considerable amount, could be added to their pay.

Good wages and an improved condition of the locality, should be an inducement to labourers to settle near the mines.

Workshops.—The Colliery Workshops are well equipped with appliances and tools necessary for the carrying out of repairs entailed by the mechanical arrangement of the collieries. They contain three lathes, two large drilling machines, shearing and punching machine, planing machine, screwing machine, seven smith's forges blown by a small fan, a steam hammer, and foundry. Nearly all appliances are made in the shops—*e.g.*, tubs, couplings, haulage pulleys, engine bearings, coke plant, appliances, brake wheel frames, pedestals, cappings, hooks, bolts, &c., &c.

All the workmen are natives, the shops being in charge of a European foreman. Castings up to 10 cwt. are made in the Company's railway workshops at Dibrugarh.

In concluding the foregoing note on the Makum Coalfield, the writer has touched upon the collieries only.

There are, besides the collieries, oilworks, and very fine saw mills, equipped with the latest designs of sawing machinery; also a large brick and pipe works.

The CHAIRMAN: I am sure you will accord Mr. Harris a hearty vote of thanks for his very interesting paper on a coalfield of which we shall now have some record in the proceedings of our Society. I move that we give Mr. Harris our heartiest thanks.

Mr. W. A. RITSON seconded the proposal and it was adopted.

Mr. GEORGE CALDWELL contributed the following "Notes on White Sandstone Nodules found in No. 1 Pit, Lord Derby's Siding, Rainford":—

NOTES ON WHITE SANDSTONE NODULES FOUND IN No. 1 PIT, LORD DERBY'S SIDING, RAINFORD.

By Mr. George Caldwell.

The Rainford Coal Company, Limited, has recently been deepening their No. 1 Pit at Lord Derby's Siding, Rainford, below the 7 feet Mine to the Arley or Bickerstaffe 4 feet Mine. After passing the Rushy Park Mine, at 194 yards deep from the surface, we found the section as follows:—

— SECTION AT RAINFORD COLLIERY —
Shewing position —
— of round white sandstone nodules —
— Scale 80 feet = 1 inch —

Depth from Surface			Strata	Description	Thickness of Strata			Remarks
				Rushy Park Mine	—	—	—	
194	0	7		Warrant	2	0	3	
				Hard Lindsey	2	1	9	containing round white sandstone nodules
206	0	10		Grey Rock	5	1	0	

The Grey Rock last mentioned contained a number of large round nodules, apparently of white sandstone, varying from three inches to eight inches in diameter. I am sending a box addressed to the Society's rooms, in Manchester, containing seven of these nodules, which may interest some of the members.

A vote of thanks was passed to Mr. Caldwell for his communication.

This concluded the business of the Meeting.

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